TERRA

THE NATURAL HISTORY MUSEUM OF LOS ANGELES COUNTY
VOL. 22, NO. 4 • MARCH/APRIL 1984

FROM THE DIRECTOR

Dr. Craig C. Black

Collections of natural history specimens, or collections in the natural sciences as they are more commonly known today, are probably the oldest *systematic* collections to be found in museums. Systematic is the key word here, as collections of things have been a part of almost every human society since man first became a social creature. Stones and bones were collected by our earliest ancestors, admittedly not for education but for survival. Sumerian clay tablets were collected and stored as documents of government, pharaonic gold, glass and pottery as symbols of eternal wealth and power, ecclesiastical relics, paintings, tapestries and other decorative arts as symbols of both mysticism and of power. The royal houses of Europe all had their collections of art and precious stones, as did the Rajahs of India and the Emperors of China. These collections were stored, gloated over, and jealously guarded, but they were not museum collections. They were rarely if ever put on exhibition, opened to public view, written about, or studied.

Museum collecting is quite different; it must be *systematic*, and it must be related to the stated purpose of the institution. By systematic, I mean that the collection must be made with an end in mind, whether it be to collect all examples of varieties within a category, all furnishings of a given historical period, or type series of biological species. Museum collections must also be documented, that is, they must come with information that places each specimen in time and space, providing an historical context for each object. Finally, museum collections must be used for public programs and for basic research.

Early natural science collections were indeed systematic, although they were often not as well documented as we would wish today. These collections formed the core of the great natural history museums of Europe and later of the United States. Many of these early collections were made by the great exploratory expeditions of the seventeenth, eighteenth, and nineteenth centuries. The von Humboldt expeditions to South America, Cook's voyages around the world, Darwin's voyage of the *Beagle*, the many French, German, and British explorations in Africa, and later the government-sponsored surveys of the western interior of the United States—all made collections of the flora, fauna, and cultural properties of the region explored and the people encountered. These collections would later form the core of the great natural history museums in Berlin, Paris, London, New York, and Washington, D.C. They also provided the basis for the initial surveys of the plants and animals of the world and for the first understanding of the world's diversity of peoples and their heritages.

During the nineteenth and early twentieth centuries natural history museum collections grew enormously as scientists cataloged the myriad plant and animal species found in the far corners of the globe. The emphasis in research was on the detailed description of this variety of life and on synoptic surveys of the floras and faunas of every part of the world. Huge collections totaling tens of millions of specimens were amassed.

Later museum research shifted its emphasis to study of the great variety of form in individual species, documenting variations within populations and in geographic races. These studies again added millions of specimens to museum collections as large series of each species were needed to provide an understanding of intraspecific variation. From these detailed studies of individual species came the information necessary for the formulation of proposals regarding the relationships of different species and the construction of family trees, or phylogenies. The detailed descriptive work of the earlier years also laid the foundations for the study of species distribution from continent to continent and for a growing interest in biogeography.

Until recent times many of the specimens in museum collections were preserved either as dried materials (mammals and birds as stuffed skins, insects on pins, sea shells in boxes, and plants pressed between paper) or in alcohol and formalin (amphibians, reptiles, fish, and many marine invertebrates). Today more and more specimens of all types are preserved in fluids or as frozen tissues so that new biochemical and microscopic techniques can be used to understand each species. New methods of preservation mean new additions to

(Continued on page 30)

TERRA

THE MEMBERS' MAGAZINE
OF THE NATURAL HISTORY MUSEUM
OF LOS ANGELES COUNTY
AND THE PAGE MUSEUM
OF LA BREA DISCOVERIES

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A mass of yellow fruit bodies of the slime mold *Trichia favoginea*, some of which are breaking open and releasing powdery spores.
Photograph by Ray Simons.
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QUICK CHANGE ARTIST: The SLIME MOLD

by FLORENCE NISHIDA

Rain! It makes the creek run to the beaches, cleaning out wind piled sycamore and alder leaves stuck in the dusty potholes of last summer's dry riverbed. Night and day, frogs sing noisily, while water splashes on encrusted rocks, bringing faded map lichens into freshly colored focus. Drops filter through the million cracks in leaf litter and fallen branches like an army of curious investigators. Then the silent and great activity of microscopic cells begins; among the fungi, mushrooms send out new feeding lines, grow, and gather energy for the tremendous push through soil and humus out to the light where they will open their parasols and release their spores.

In the same woods, on myriad sticks, logs, and curled up old leaves, another silent and microscopic activity—one of the most fantastic in the world of biological phenomena—is taking place. A dried-up crumb turns moist and alive, pushes out a tail, and begins swimming in search of a mate. Animal-like? Yes. But in minutes or hours, it and other dried crumbs that have come to life will merge as if by magic into a glossy, streaming, motile patch of wet, naked protoplasm. These are fungal-like organisms that produce spores and yet are so unlike the fungi that their classification is still open to question. They are members of the class Myxomycetes, or "slime molds," whose free-living and motile feeding stage looks quite unlike either the reproductive or propagative (spore) stages. It would be as bizarre a scenario if the leaves of a tree fell to the ground and some began to acquire tails for swimming, while others simply became oozing walkers. Then, after milling about in this fashion for a time, they all at once would converge into a wet yellow asphalt-like flow that moved slowly along the ground, eating whatever became available—a tricycle, a garbage can, an unlucky dog or cat—by engulfing and digesting it. Then, the "asphalt," having "cleaned its plate," would gather itself up into a towering tree again, its ooze gradually differentiating out into leaves. Such are the transformations occurring on a miniature scale among the myxomycetes.

Myxomycetes, with 500 species worldwide and about 400 in North America, are a small group compared to the kingdom of fungi (where they have been traditionally placed), which has an estimated 60,000 to 100,000 species worldwide. Botanists had considered fungi lower plants, but current thinking is that the fungi are indeed a separate kingdom, neither plant nor animal. Because myxomycetes are generally found in the same habitats as fungi—on wet logs and other decomposing plant material—fungi specialists initially collected and studied the slime molds. But, even as early as 1859, Anton De Bary—one of the first of the serious students of slime molds—stressed their animal quality by his name for them: Mycetozoa, or "fungus animals." The name fell out of use, however, as mycologists rather than zoologists persisted in describing and categorizing new species. In 1753, the famous botanist Carl Linnaeus had described and named five species, establishing the starting point for the nomenclature for the group. But like many of his contemporaries, he was merely taken with the colorful streaming state and remained unaware of the full and intriguing life cycle of these organisms.

But you have never seen these strange creatures, you protest. In fact, they are not rare so much as simply overlooked. Slime molds are the most cosmopolitan of organisms, being found from the Arctic to desert places (Dr. Robert Gilbertson in Arizona has recovered slime molds from rotted saguaro cactus collected in the Sonora Desert—the spores remained viable after laboratory exposure to temperatures exceeding 1000°F). However, slime molds are mostly abundant in wooded areas.

It is a special pleasure to walk in humus-smelling wet woods, picking through piles of dark twigs and pulling apart rotting logs in search of slime molds. Their bright splatters, like fresh paint, catch the eye. But if we were suddenly to be reduced to the size of a red mite and to linger in the woods past the setting of the sun, wandering about on the substrate that the wet slime mold occupies, we would be confused by its changing guises and finally threatened as several of the creatures joined to become a moving blob.

In contrast to seed germination in plants, or mushroom spore germination (in which a more or less rigid tube is formed), spore germination in the Myxomycetes results in motile protozoan-like creatures that quickly enter into a reproductive phase. Under wet and rather warm conditions (70 to 86°F), the spore walls crack open, and out crawl one to four slithery amoeboid bits of protoplasm called *myxamoebae*, each containing a single nucleus. Or, in the presence of small puddles of water, the spore will yield tiny, swimming bits of uninucleate protoplasm *(swarm cells)*, which propel themselves on course with two flagella (whiplash tails) at the head end (although properly speaking there is no "head"). Incredibly, the amoeboid form is capable of producing flagella within 60 minutes, a feat similar to our sprouting fins as we walked down toward the beach intending to swim. And, if conditions become drier, the swarm cell swimmer is capable of drawing the flagella up against itself, reabsorbing them, and becoming indistinct from its false-footed brethren, the myxamoebae.

The wandering and swimming about of these bits of protoplasm eventually comes to a point. Whatever form they have taken, they are eating, occasionally increasing their numbers by cell division, and looking about for a compatible mate. When they succeed in finding a mate, copulation usually results first in a fusion of protoplasm and then in a fusion of the two nuclei. This sexual union can take place between two swarm cells or two myxamoebae or even between a

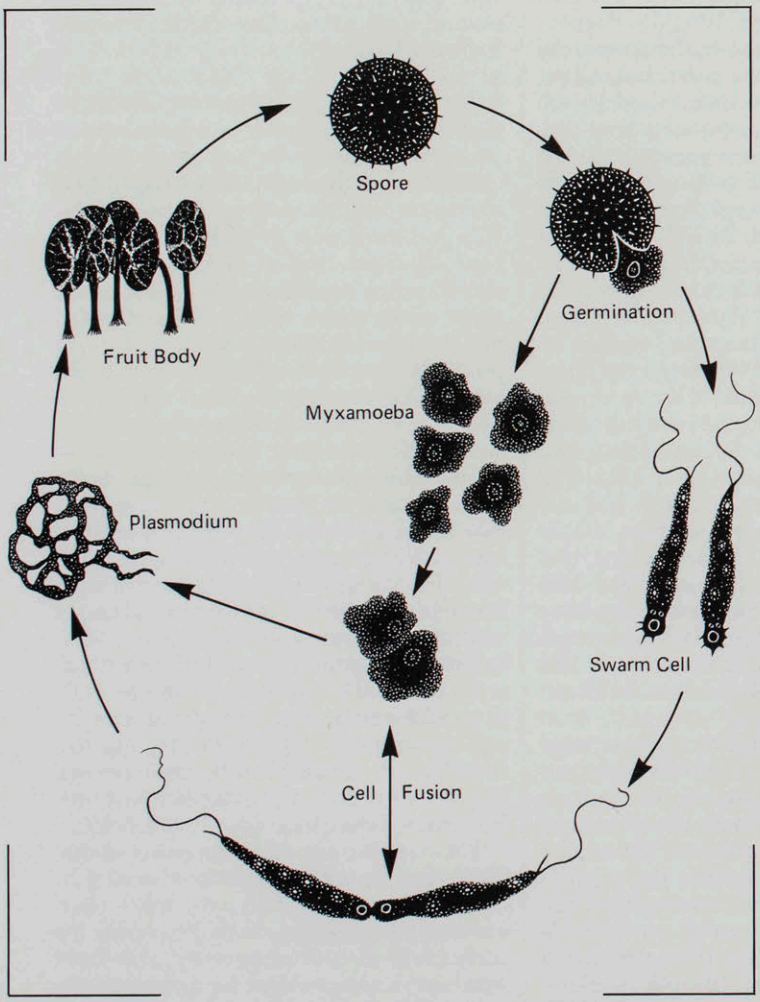
swarm cell and a myxamoeba. Sometimes a perplexed cluster of myxamoebae or swarm cells will stand together, but generally a group fusion does not take place. Recall that we are still bystander mites, and we are amused by all these transformations and copulations. But things are about to get stranger.

The now combined-nuclei *zygote* is a more ambitious and assimilative being, in search of others like itself for the primary objective of attaining greater size. The zygote is unflagellated and continues life as a naked (unwalled) cell, feeding by engulfing bacteria and fungal mycelium and spores and moving in constant search of food. It enlarges, becomes multinucleate as several zygotes coalesce, but nevertheless remains technically a single cell that behaves with a singleness of purpose. It is hard to imagine a clump of earthworms, a flock of birds, or a committee of persons coalescing into one massive body, mostly by rubbing next to each other, and then keeping all their heads together and operating as one mind. But this is the behavior of the slime mold *plasmodium*. The plasmodial stage of myxomycetes is an anomaly in the scheme of biological classification. Its unwalled multinucleate form fails to easily fit into the accepted cell theory wherein every living being, from elephants to mold, is organized into units of protoplasm contained within a cell wall or membrane, each with a control center, usually a single nucleus.

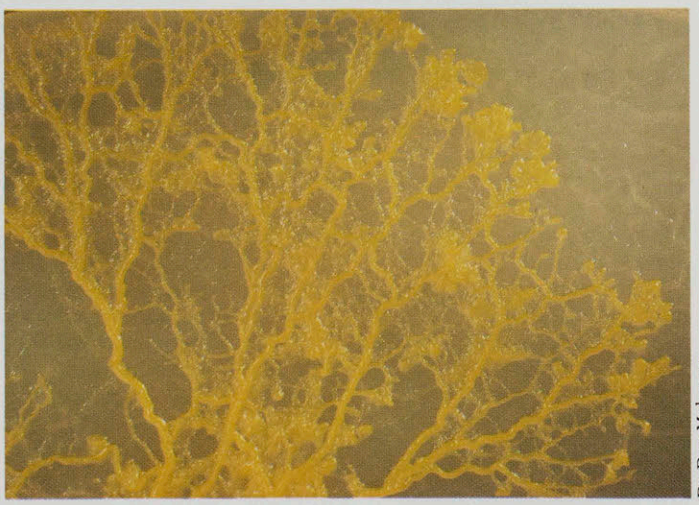
The plasmodium is a determined consumer, its forward flank moving with searching fingerlike projections that radiate out in several directions. It assimilates every reasonable meal in its path, thus changing the blobby shape of the growing zygote into a moving network. Mushroom spores that are lying about and fungal strands that are woven in and out of crevices in the log, being immobile, are gradually surrounded so that they find themselves on the inside of a food vacuole and the central object of plasmodial absorption. Bacteria skittering about succumb to the same fate as they are simply overwhelmed by a greater, motile body. The plasmodium moves along, making choices. If the potential meal is too large to surround and eat, it is bypassed. Mites can presumably outrun it. Whatever is indigestible is excreted and left behind in the trail. Occasionally a bit of the plasmodium will take it into its head to leave the main body and simply break off, returning to the independent life of a swarm cell or myxamoeba. But such desertion of the ranks is rare.

Thus, the plasmodium grows outwardly, both by absorption of food and by accretion of other myxamoebae or zygotes. Inwardly it grows by division of nuclei, so that hundreds of nuclei may be contained in one single plasmodium. Its diameter may range from a fraction of an inch up to 8 inches, but it occasionally reaches an alarming size. One plasmodium of *Physarum cinereum* was reported in 1937 to have formed a "fairy ring" encircling an area of about ten square feet.

When viewed under the low power of

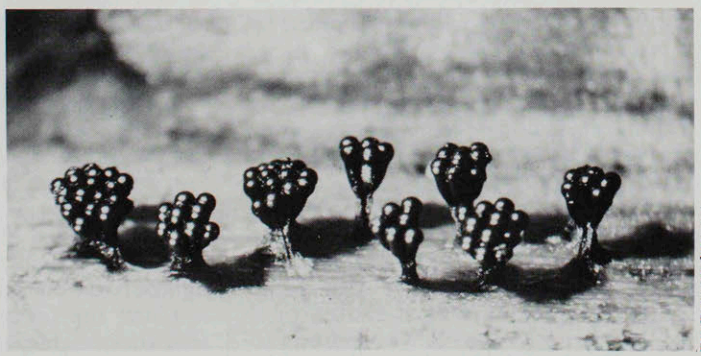


The life cycle of the slime mold. Illustration by Mary Butler, Museum Illustrator.



Dr. Dan Mahoney

Plasmodium. This structure is the feeding and growth stage of the myxomycete life cycle. The appearance of this slowly moving protoplasmic mass gives the group its common name—slime molds.



Dr. Dan Mahoney

These young fruit bodies of Metatrichia vesparium *are not quite mature. The plasmodium has transformed into a stalk; the shiny cluster of balls is undergoing the change into spores and capillitium.*

the microscope, the streaming of one type of plasmodium reminds one of the slow, inexorable movement of lava during volcanic eruptions: each vein or fingerlet consists of an outer layer, where there is no movement, and an inner core of streaming protoplasm. The protoplasm streams forward in one direction, then stops, and begins to flow in the opposite direction. The steps forward are greater than the steps backward, so that the net effect is locomotion. The streaming appears to involve changes in the viscosity of *myxomyosin* (a contractile protein) when it interacts with ATP (the enzyme adenosine triphosphorus).

A second type of plasmodium, which is easily overlooked because it is colorless, often makes its searches for food on the inside of logs: instead of spreading out in wide, venate sheets, it spins itself out in long, separate, nearly invisible strands.

The weather has been growing drier and drier, and our log surface no longer has free-standing water. The multinucleate being starts to reorganize itself; the nuclei, with their surrounding bits of protoplasm begin gathering together at various assembly points. No one knows yet exactly how the signals are called, but certainly biochemicals are involved, and some combination of influences, not completely understood, suddenly causes the plasmodium to leave off its streaming, growing phase and to mobilize its activity toward *sporulation* (the formation of structures or fruit bodies in which spores are formed). Changes in light seem important for sporulation in yellow pigmented plasmodia but not in others. Loss of nutrients can trigger sporulation, and the serious threat of dessication appears to influence the decision as well. However, "ripeness is all" even with the slime molds, and very young plasmodia without the proper level of biochemical maturity cannot be forced to sporulate. There is also a "commitment to sporulate" point in the process, after which it is not possible to go back to the plasmodial stage, even if nutrients are supplied.

The transformation is spectacular. There is a striking loss of cellular water: the plasmodium is 80 percent water, whereas the spores are only 20 percent. Water loss is not due to simple evaporation but to a forcible extrusion of water. In the transition from plasmodium to fruit bodies, a new substance, the cell wall, has to be made. Water may be formed as a byproduct of the new combinations of large molecules being formed. The signals are called, and the protoplasmic mass with its hundreds or thousands of nuclei gathers itself together, mounds up, and restructures itself into one of a myriad of fruit body types.

The fruit body types form the basis for the classification of slime molds. *Sporangia* are discrete, upright spore balls on stalks less than ½ inch tall that are frequently found standing in troops. A *plasmodiocarp* may maintain its network form and simply develop a *peridium* (wall) around the thickened veins, looking very much like a knotted pretzel. The plasmodium of the science fiction blob type develops a peridium on

Dr. Dan Mahoney

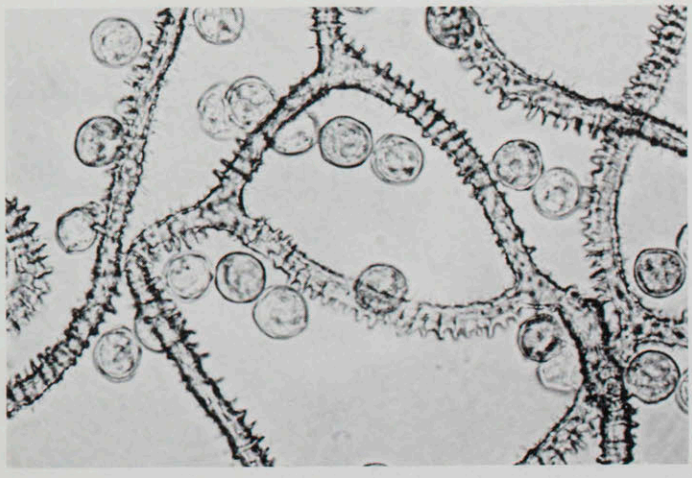
Sporangia of Arcyria denudata *appear as stalked shiny masses when immature and as reddish plumes when the spores and capillitium are fully formed.*

John DeLeon

The sporangia of Arcyria incarnata *on tree bark. The capillitium of some fruit bodies have expanded causing the spores to be released.*

Dr. C. J. Alexopoulos

Capillitial threads curl over the top of the goblet-like sporangia of Arcyria ferruginea.



Dr. Dan Mahoney

The capillitium of Arcyria nutans *is ornamented with microscopic spiral bands and cogs. As the threads expand and contract, the rounded spores are flung from the fruit body.*

the outside, while the inside mass carves itself up into thousands of spores; this *aethalium* type fruit body can be seen for months on the soil as a gradually thinning pillow of fine purple-brown dust. Intermediate between the stalked and pillowlike forms is the *pseudoaethalium*, a tightly clustered group of sporangia resembling a beehive or, after the spores have spilled out, a clutch of wine goblets.

The mechanics of restructuring is one of the marvels of nature. In the sporangiate forms, the dispersed protoplasm begins single-mindedly to concentrate in areas of the main strands, where it accumulates into nodules. Each arriving bit of plasmodium begins to climb up over the first arrivals; as they pile up, a pillar is formed. The outer surface differentiates into a thick, tough wall, while a foamy structure develops on the inside, upon which spores will be formed. A central core of granulate material provides a skeleton. The protoplasm continues migrating into the top of this pillar-stalk, pouring in new building ma-

Slime Mold IN THE LABORATORY AND IN THE SUPERMARKET?

Slime molds are useful in genetics research because of their short life cycles, distinct stages, and rapid responses to changes in their environment. The myxamoebae are easy to care for in the laboratory—they can be kept alive on a diet of dry oat flakes or bacteria soup.

Myxomycetes may someday become more familiar if their potential as a food source is ever exploited. Most other organisms studied as possible fast-growing food sources—such as algae, plankton, fungi, yeast, and bacteria—have the disadvantage of having indigestible, rigid cell walls. But the myxomycete plasmodium, which has a high percentage of protein, has no rigid chitinous or cellulose-containing cell wall. And because of its animal affinities, myxomycete plasmodium contains proteins that might be more suitable for use by humans than many of the presently used vegetable proteins. Various enzymes, vitamins, and sterols have been detected in the plasmodium of *Physarum polycephalum*, a well-studied species of slime mold; several other species even produce antibiotics.

Dr. Dan Mahoney

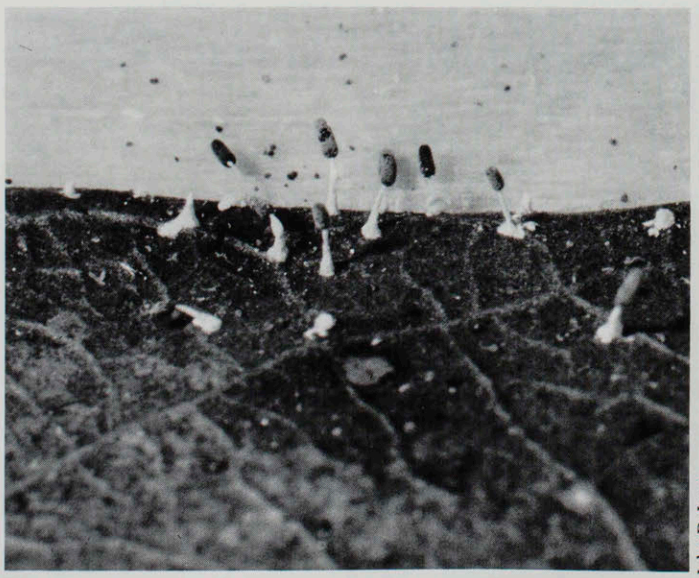
A clump of Stemonitis axifera *sporangia on wood.*

John DeLeon

Ripley referred to sporangia such as these of Stemonitis splendii, *which are growing on wood, as Believe-It-Or-Not hair.*

Dr. Dan Mahoney

A microscopic view of the sporangial capillitium of Stemonitis smithii. *Earlier, the branching network contained a mass of spores.*



John DeLeon

The sporangia of Diachea leucopodia *are borne on lime-encrusted stalks.* Leucopodia *means "white footed."*

terials. The outer membrane finally begins to form a peridium, closing up over the frothy spore-producing structure. On the inside of the globose or club-shaped "head" of the sporangium, protoplasm surrounding each nucleus is carved out and walled to form spores. In addition, a *capillitium*, a system of threads, may form in some species. The capillitium may be highly organized, frequently into arborescent forms resembling miniature winter birch trees or glassy networks. In some species, the capillitium consists of separate, serpentine, pale yellow strands, elaborately decorated with rings, cogs, or spines. The strands of this latter type of capillitium often act as *elators*, uncoiling and flinging spores abroad after the peridium is ruptured by raindrops or passing animals.

In the plasmodiocarp or aethaliate species, the plasmodium throws out its salt-laden water. As the water evaporates, the salts, usually calcium carbonate, are deposited on the outside, forming a limy surface. The limy peridium of some species is blue-violet, iridescent, and exquisitely fragile; in others, it is white, smooth and porcelanous, scaly, or stellate. Nonlimy species tend to have tough, leathery peridia.

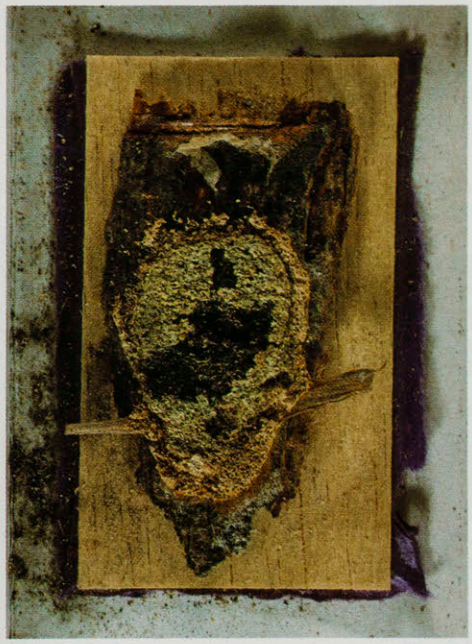
Through the long weeks of dry weather, over the months of summer and fall, the wind tears at the evanescent peridium, and scuttling insects and other animals shake off more bits of its covering and disturb the exposed powdery spores. Some of the spores are stirred up into the air and fall into another log or debris, some remain in the remnant cups of stalked sporangia. All patiently await the drops of next season's rain, the running water that is necessary to stir both fungi and slime molds into active life. The nucleus and its potential protoplasm wait, safely protected from dessication, until wet and rather warm conditions exist again. The spore walls will then crack open, permitting the escape of either the flagellated swarm cells or the myxamoebae to start the life cycle again.

Although the cyclical nature of the Myxomycetes is a familiar theme in the biological world, its life cycle is an inventive combination of (1) microscopic motile existence (the amoeba-like swarm cell or the flagellated myxamoeba), (2) formlessness (the plasmodium), and (3) organized, structured fruit bodies. No other organism displays such stunning quick-change artistry, responding so rapidly and successfully to sudden environmental stresses, nor so uniquely occupies both the animal and fungal worlds. The slime mold exploits the dualities of Nature—light and darkness, motility and sedentariness, moisture and aridity.

Florence Nishida has collected and studied mushrooms of southern California since 1979. As a Museum Associate of the Botany Section, she handles inquiries from the public concerning mushrooms and has organized two special exhibits on these fungi. She is currently pursuing a degree in mycology; her main interest is in taxonomy, particularly of the mushroom genus Inocybe.

John DeLeon

The sporangia of Didymium hemisphericum *are studded with stellate lime crystals.*



John DeLeon

A lime layer covers the spore mass on the aethalial fruit body of Fuligo septica. *The spores are blown away as the aethalium erodes away. (The myxomycete is attached to a matchbox here; this is a method of specimen preparation that protects the myxomycete during transportation from the field.)*

Dr. C. J. Alexopoulos

The aethalial fruit body of Physarium borgoriense *bears spores wrapped in brownish lime petals. The spores and limy capillitium are exposed as the outer cover falls away.*

John DeLeon

The fruit body of Cienkowskia reticulata *maintains the form of the reticulate plasmodium and is called a plasmodiocarp.*

The Collections of a Young Museum Grow

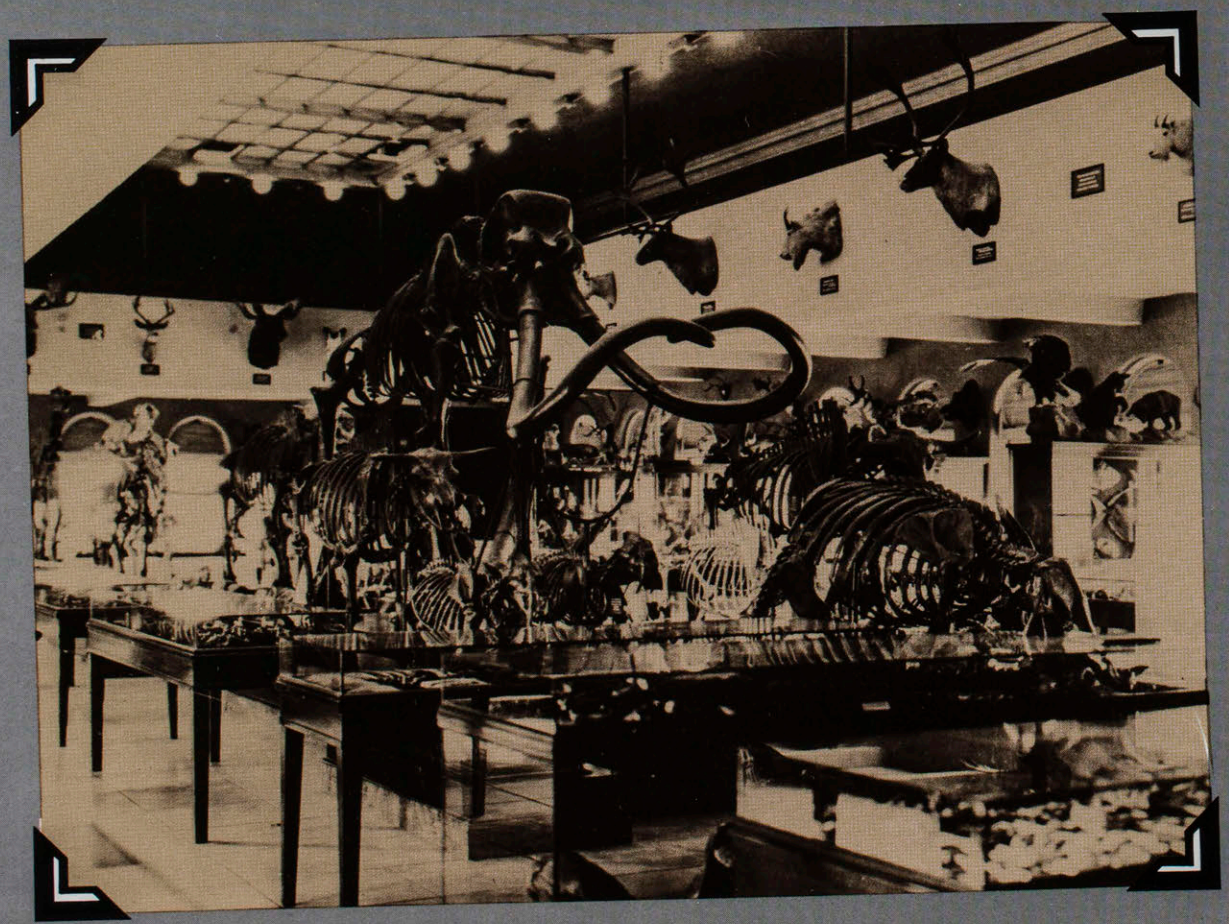
The nucleus of the Natural History Museum's paleontology collections, and indeed one of the major factors in the founding of a natural history museum for Los Angeles County, was a treasure trove of 750,000 bones from the Rancho La Brea tar pits recovered between 1913 and 1915. For many years the most spectacular specimens from the tar pits were on display, together with the skeletons of many modern mammals, in what was then Hancock Hall and is now the California Fossils Hall of the museum. In 1925 the second director of the museum, William Alanson Bryan, commissioned the famous artist Charles R. Knight to paint a mural depicting restorations of the Rancho La Brea fossils in what was then thought to be their natural habitat (see TERRA, Winter 1982). This mural is still on display although most of the Rancho La Brea fossils have long since been moved to the Page Museum of La Brea Discoveries, and the California Fossils Hall is now scheduled to be replaced by a new North American Indian Hall.

Today the museum has a staff of eight vertebrate paleontologists (including the Director), but in 1929 there were only two—Dr. Chester W. Stock (who had only a half-time position; the rest of each year he spent teaching at the California Institute of Technology in Pasadena) and Dr. Hildegarde Howard. Nevertheless, with the enthusiastic aid of a small preparatory staff and local volunteers, the vertebrate fossil collection grew apace to become one of the largest in the nation.

Two of the articles in this issue of TERRA provide insights into the techniques used in collecting fossils 50 years ago and the people instrumental in the growth of the collections of a young museum. In "The Mystery of Bishop's Cap Cave," Dr. Mary Elizabeth King describes the discovery of ancient human remains and associated animal bones in a cave in New Mexico in 1929, the subsequent excavation of the cave by museum staff, and some questions concerning the excavated material that are still waiting to be answered. There are also some unanswered questions about the museum's fossil whale specimen from Lincoln Heights, which was acquired in 1931; Drs. Giovanni Bussino and Lawrence G. Barnes describe the recovery and importance of this 10 to 11 million year old specimen. Together the two articles underscore the enduring value of the museum's collections for both exhibits and ongoing studies.

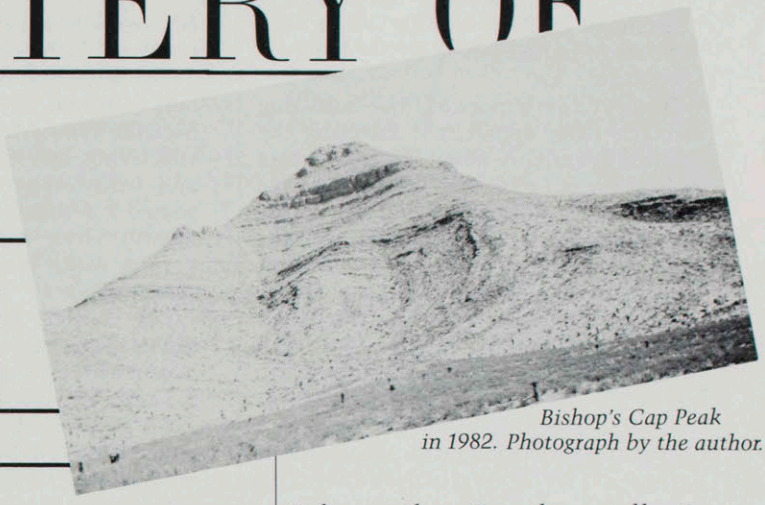
JOHN M. HARRIS
Chief of Earth Sciences

The Natural History Museum's Hancock Hall (now the California Fossils Hall) in the 1920s. Photograph from the Museum Archives.



THE MYSTERY OF BISHOP'S CAP CAVE

by MARY ELIZABETH KING



Bishop's Cap Peak in 1982. Photograph by the author.

When Bishop's Cap Cave in south-central New Mexico was first scientifically investigated in 1929 by the Los Angeles County Museum, William Alanson Bryan, then Director of the museum, called it the "most important find in prehistory ever made." Bishop's Cap, a limestone sinkhole or fissure in the southern Organ Mountains, contained human skeletal remains in probable association with Late Pleistocene mammals. At the time of its excavation by the museum, the cave appeared to provide the best evidence placing humans in the late Pleistocene (before 10,000 B.C.) in America yet discovered. Mysteriously, however, the results of the excavation were never fully published. Though the cave's contents and records were carefully preserved in the cabinets and file drawers of the museum's Vertebrate Paleontology Division, they have been virtually ignored by later scholars of the Pleistocene.

In the late 1920's, seventy-odd years after the publication of Darwin's *Origin of Species* and with the Scopes "monkey trial" still very fresh in the public mind, there was considerable controversy about the earliest dates for the human occupation of the New World. Aleš Hrdlička, of the U.S. National Museum of Natural History, the leading and most vocal physical anthropologist of the day, had publically criticized all previous finds suggesting that humans had coexisted with Pleistocene mammals in North America. While Hrdlička was willing to accept a post-glacial date for human migration to this continent, he quite reasonably demanded rigorous proof.

In 1929, the possible instances of "early" humans in North America probably consisted of fewer than two dozen finds. Some of these were isolated human remains, others were tools associated with extinct mammals, and only a few were "associated" human and extinct animal remains. In most cases, either the associations or the geology were highly questionable. Several of the discoveries, however, did suggest that humans and extinct animals were indeed contemporary. On the basis of these finds, claims were put forward that humans had reached the New World as early as the Pliocene (2 to 5.2 million years ago) or Miocene (5.2 to 23.7 million years ago), and it was even proposed that humanity originated here in the Eocene (38 to 59 million years ago). Small wonder that reputable scientists of the early 20th century were extremely cautious in their pronouncements.

It is thus both understandable and perhaps a little surprising that, when Bryan received a letter dated March 11, 1929, from a resident of El Paso, Texas, detailing the discovery of an ancient human skull and illustrating some of the associated animal bones, he responded with alacrity on March 13th.

> Your paleontological discoveries are of great interest to this museum. So much so, in fact, that I am seriously considering a trip to El Paso in order to confer with you as to the possibility of our exploring the exposures and securing some of the material for this institution.

This interchange began a relationship between Roscoe P. Conkling, an engineer and statistician employed by the American Smelting and Refining Company of El Paso, and the Los Angeles County Museum that was to last for many years and that produced several important collections for the museum. It also represents an object lesson on the importance of answering seemingly unimportant mail. Nearly identical letters that Conkling addressed to the Smithsonian Institution, the American Museum of Natural History, and Peabody Museum, Harvard, were never answered at all. Had it been otherwise, these collections might now reside in Washington, New York, or Cambridge. Only a few months later (on June 10, 1929), Dr. Chester Stock, Vertebrate Paleontologist at the museum, wrote Conkling: "Barnum Brown [then a vertebrate paleontologist at the AMNH] was through here the other day and seemed to be very much interested in the cave that we are opening up. I think he was somewhat disappointed over the fact that the American Museum passed up a good opportunity."

By April 17th, Bryan was in El Paso, and, having investigated Conkling's finds at Bishop's Cap Cave in nearby New Mexico, telegraphed the Los Angeles County Board of Supervisors:

> After careful examination of occurance [sic] and fossils recovered from Bishop Cap Bone Cavern here am convinced it is most important find pre-history ever made as absolutely connects man with extinct La Brea animals stop.

Bryan requested money to purchase the material. One thousand dollars was duly sent, paid not to Conkling but to his workmen, and five barrels of bones were shipped immediately to Los Angeles.

The cave had actually been explored by four residents of the area, Nicanor Mestas, Lorenzo Benavides, Jose Benavides, and Richard Chapman, in January of 1929. How Conkling came to be involved is not entirely clear. One story has it that he saw the bones that had been found in the cave exhibited in the window of a store in Mesilla, New Mexico, a small town near Bishop's Cap Peak. Bryan, however, indicated that, in pursuing his hobby of archaeology, Conkling arranged for the men:

> to locate promising caves within reach of El Paso for him to leisurely explore and study. Their acquaintance from youth with the mountains in the country surrounding El Paso and the first-hand knowledge of

a local tradition to the effect that Spanish gold had long ago been buried in the small dark cave on Bishop's Cap Peak prompted them, under Mr. Conkling's encouragement, to go there and dig — not for bones or Indian relics, but for buried treasure....

However it happened, the four dug into the cave, apparently enlarging the original opening of about 3 feet by 4 feet by blasting out rock. The floor of the cave was, at that time, about 8 to 11 feet below the opening, but this appears to have been the result of an earlier excavation by the father and uncle of Lorenzo Benavides and Nicanor Mestas. At about 10 feet below the floor, the four encountered bone and thought it to be "perhaps the bones of a mule that might have belonged to the owners of the supposed buried treasure. As a result, the work of excavation went feverishly on, until a fragment of a human skull was exhumed!" It was then that Conkling came on the scene, and Bryan relates that "he then took active charge of the excavations and carefully supervised the further exploration of the cave."

Before the museum could get a crew onto the field, the workmen had reached the old floor of the cave and had removed a number of bones, apparently including two more human crania, sloth, horse, and other animal remains. On May 7th, J.W. Lytle, who held the positions of Preparator and Assistant Vertebrate Paleontologist at the museum, arrived in El Paso to supervise the work. Although Bryan had originally intended to send only one man, subsequent separate trips to the site by Drs. Chester Stock and John Comstock, Associate Director, convinced both men that additional trained help was necessary. Accordingly, Wesley Bliss and Henry Wylde were dispatched to expedite the excavation, arriving on May 30th.

In excavating the cave, the workmen had cut through a "diaphragm seal" of consolidated limestone matrix at about 20 feet below the cave opening. This "seal" was of extreme importance in understanding the site and the relationships of animals found within it. Remnants of it were still in evidence when the LACM crew arrived. There is no doubt in the minds of Bliss and Wylde today that the human crania were associated with bones from sloth and other extinct animals and that these all came from beneath the seal. As Bliss recalls, most bone from beneath the seal was coated with a deposit; bone from above the seal was not. This is a critical point since the actual excavation of the human crania was not observed by Los Angeles Museum personnel.

The cave in which the fossils were found had actually been known locally for some time. At some point in the last quarter of the 19th century, two residents of Mesilla were prospecting in the area and using the cave as a camping place. Conkling described the discovery of the cave:

> Almost 50 years ago, two of the early settlers, Zeferino Benavides and Turbucio Misques, employed by Albert Fountain, Sr., of the old town of Mesilla, New Mexico, and who are still living, one now in his 87th year and other approaching 80, prospected for minerals in the hillside within a few hundred feet of the cavern, using the cave shelter for a camping place.
>
> The mineral prospects not proving encouraging, their imaginations became fired by a legend of Spanish mule trains, laden with bullion, on their way to Mexico City, having been attacked by hostile Indians who massacred the party and threw the treasure into nearby caves.
>
> Deciding to institute a search, they began excavating the floor of this cavern, and, at a depth of 10 feet, uncovered some bones and teeth, which they removed.
>
> Sitting beside their fire that same night in the dark hole, they were startled when a black figure, bearing a lighted candle, entered the cavern, and, as they described the incident to me, the apparition spoke, saying: "Buenos [sic] noches" and vanished forthwith.
>
> The following day, still frightened by their experience of the night before, the men filled up the excavation, placed the bones in a sack and carried them to their home, some 11 miles distant, where, on the advice of a local priest, they buried them in the nearby cemetery.

There was some question as to whether the bones were human or nonhuman, and, when Wes Bliss and Henry Wylde heard the story of the earlier excavation, they took it upon themselves to investigate further. They interviewed Misques, and Bliss searched for the bones in question in the old Bosque Seco cemetery, where he found part of a humerus and a lower jaw that Wylde identified as those of a bear. Conkling was not pleased by their "wild goose chase," as he called it. In a letter to Bryan, he wrote somewhat testily that "I feel as I always have concerning this, that the material first discovered at the ten foot level as they explained to me was *animal* material and not *human*. That they came upon our first level containing bear and Sloth [sic] material has always been my belief but I do not know how it can ever be positively confirmed. I feel, at this time, that this is a question that should be left to older heads to decide...."

Bliss and Wylde were, indeed, young and high-spirited. Bryan, in his letters to them, almost always addressed them as "My dear boys," and he sometimes referred to them as "Messrs Wylde, Bliss Corporation, Excavators." Lytle, their supervisor, was in ill health and homesick and often appears to have left matters largely to "the boys." Lytle sometimes called Bliss "the gopher," because he so often crawled into new portions of the cave. Stock, the museum paleontologist, visited the site occasionally, but he was much occupied by other matters, including illness in his family. The on-site museum employees were aided by several local workmen, including Nicanor Mestas and Lorenzo Benavides.

There was a prevailing air of excitement in camp, heightened, no doubt, when a visiting anthropologist, A.E. Jenks, of the University of Minnesota, told the crew that Lytle might become more famous than Roy Chapman Andrews. In his diary, Bliss records, "this anthropologist said that [we] would in all probability; find Pith. Oh boy, I hope so." "Pith," of course, refers to *Pithecanthropus erectus* (now *Homo erectus javanicus*), an early fossil human type that had been discovered in Java.

From that day on, the crew sought avidly for "old man Pith," as Bliss sometimes jokingly called him. Although they found bits of human bone almost daily, they could not duplicate the original finds of relatively intact crania, and no whole human skeletons appeared in the previously untouched areas of the cave. Whole sloth skeletons, on the other hand, were not uncommon. Conkling found one; the boys found two.

On July 19th, Lytle left camp for Los Angeles, leaving Bliss and Wylde in charge. Shortly after the truck left, a downpour toppled the carefully maintained stratigraphic column within the cave. For several days, letters to and from the museum dealt with how this could have happened and what it might imply regarding the formation of the cave's seal. After the rains subsided, Wylde

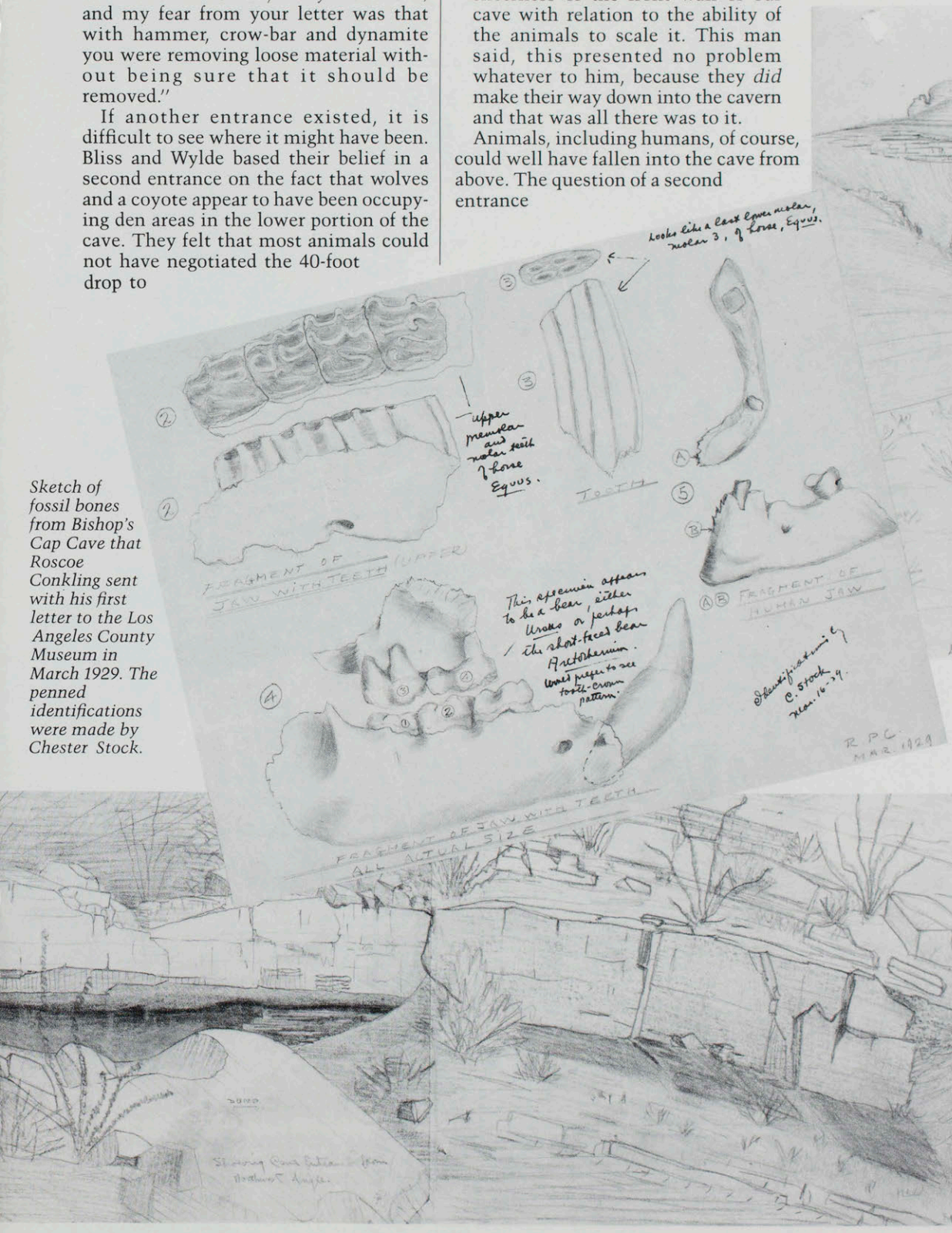
wrote Bryan requesting permission to remove some large rock from the floor of the cave, inasuch as it was in their way. Bliss, convinced then, as he is today, that there was originally a "walk-in" entrance to the cave, decided to carefully dynamite some boulders in order to make removal of the rock easier. Bliss wrote Bryan of their efforts and received a cautioning reply "while we are anxious to find the entrance to the cavern if one existed and was subsequently closed, *we do not desire to artificially make one,* and my fear from your letter was that with hammer, crow-bar and dynamite you were removing loose material without being sure that it should be removed."

If another entrance existed, it is difficult to see where it might have been. Bliss and Wylde based their belief in a second entrance on the fact that wolves and a coyote appear to have been occupying den areas in the lower portion of the cave. They felt that most animals could not have negotiated the 40-foot drop to the floor of the cave. On this subject, Conkling wrote Bryan:

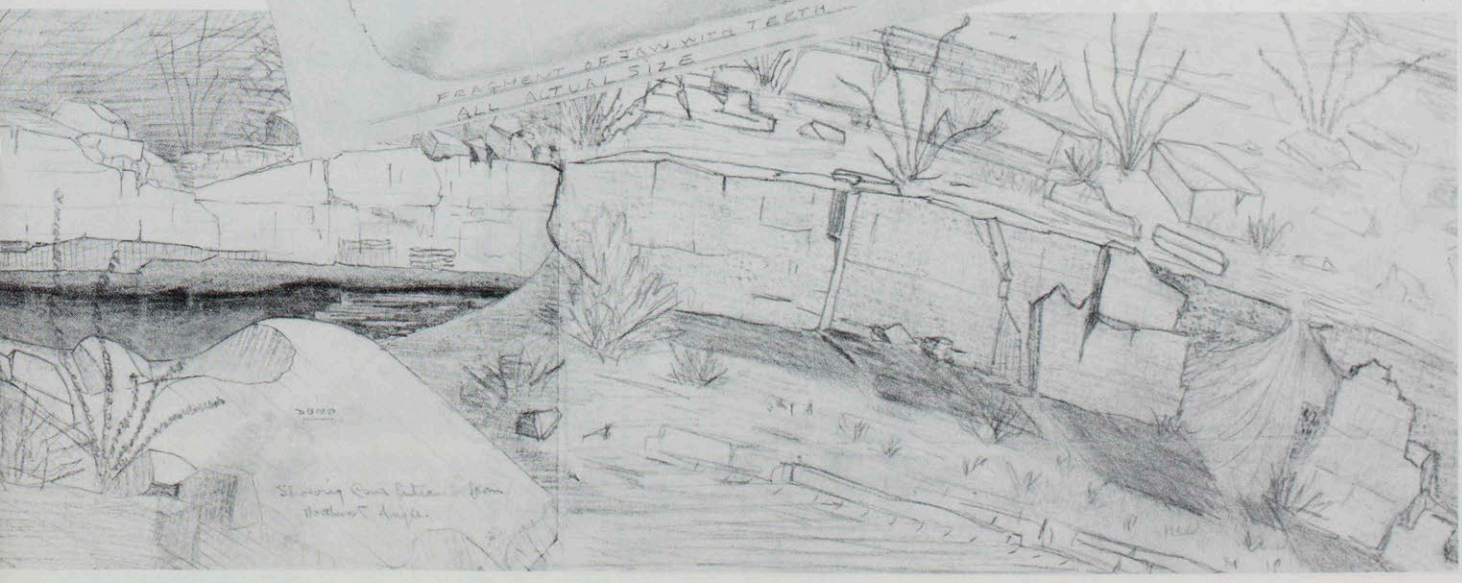
> An interesting letter came from Mrs. Vear [the future Mrs. Conkling] who stopped at Chicago on her way to New York where she is attending Columbia college. She was acquainted with a Scientist from the Field Museum who had just returned from South America with some sloth and other material. She mentioned the condition of the sheerness of the front wall of our cave with relation to the ability of the animals to scale it. This man said, this presented no problem whatever to him, because they *did* make their way down into the cavern and that was all there was to it.

Animals, including humans, of course, could well have fallen into the cave from above. The question of a second entrance is thus one that must still be resolved.

Meanwhile, word of the cave had begun to spread to the world at large. On his return to Los Angeles in mid-April of 1929, Bryan wrote a brief article on the cave and submitted it to *Science,* where it was published in the July 12th issue. On May 5th, Bryan wrote Conkling that it "seemed advisable to Dr. Stock and me to give a newspaper report based on the material you sent to the Los Angeles


Looks like a last lower molar, molar 3, ? Horse, Equus.
upper premolar and molar teeth ? Horse Equus.
TEETH
FRAGMENT OF JAW WITH TEETH (UPPER)
This specimen appears to be a bear, either Ursus or perhaps the short-faced bear Arctotherium. Would prefer to see tooth-crown pattern.
AB FRAGMENT OF HUMAN JAW
C. Stock
R P C
MAR. 1929
FRAGMENT OF JAW WITH TEETH
ALL ACTUAL SIZE

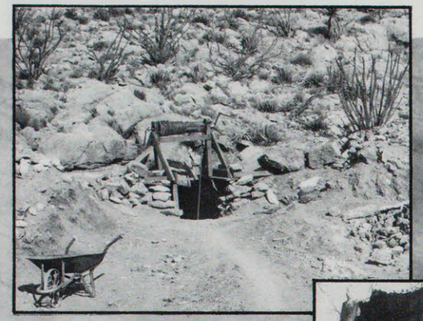
Sketch of fossil bones from Bishop's Cap Cave that Roscoe Conkling sent with his first letter to the Los Angeles County Museum in March 1929. The penned identifications were made by Chester Stock.



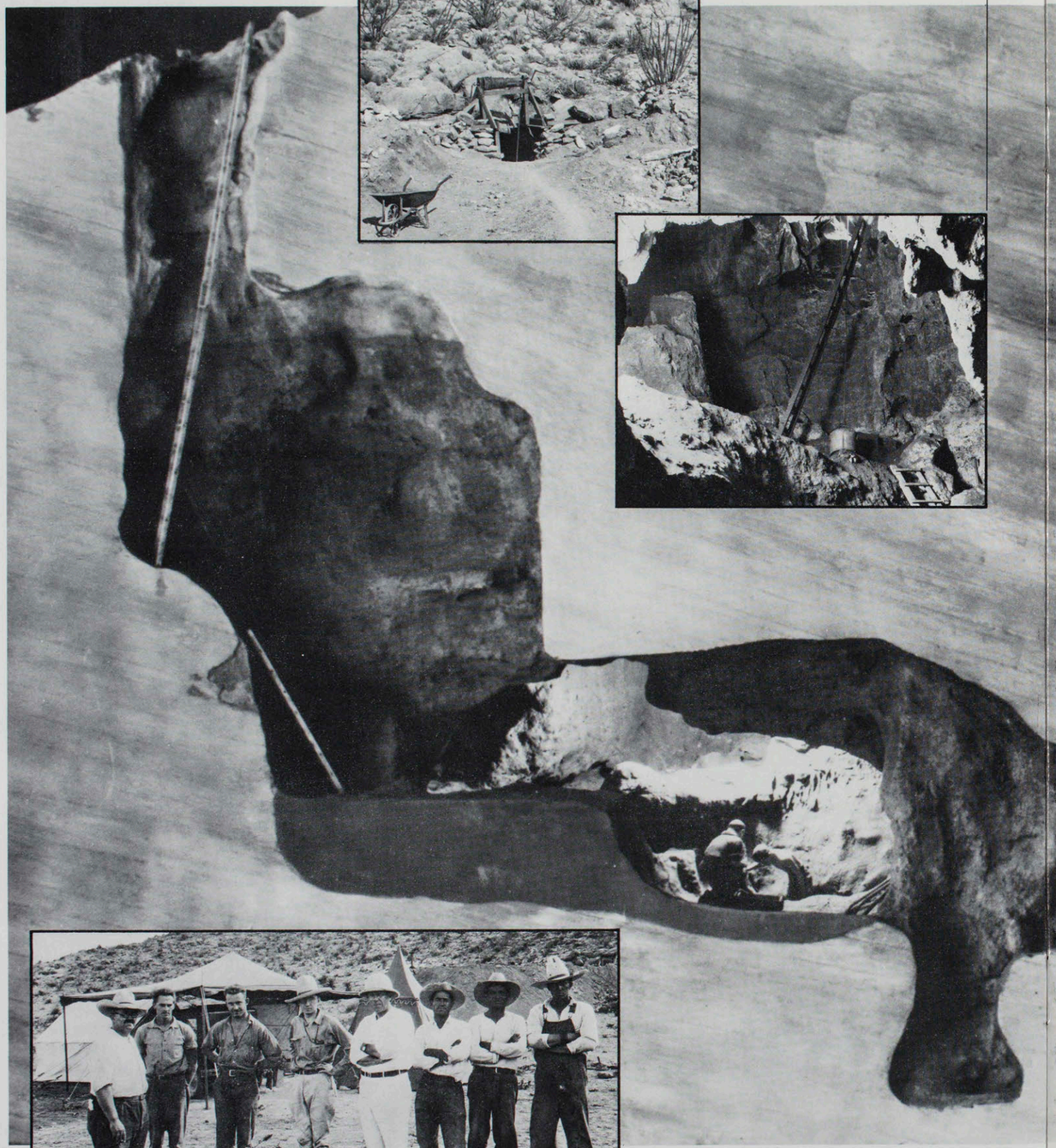
Wylde's sketches of Shelter Cave (top) "showing cave entrance from northwest angle" and Bishop's Cap Peak (bottom).

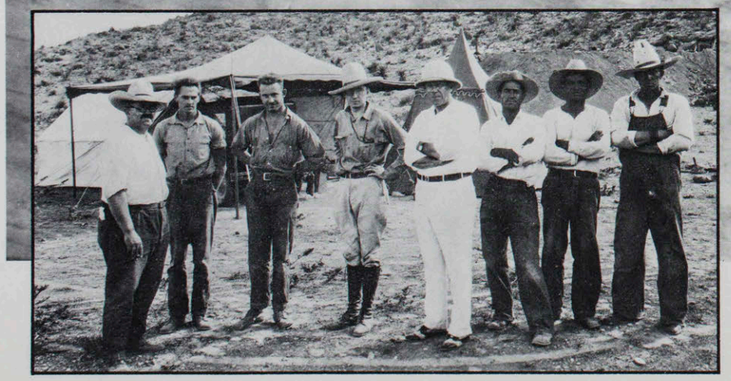
Henry Wylde's model of Bishop's Cap Cave made for exhibition at the museum.

The entrance to Bishop's Cap Cave with winch in place.



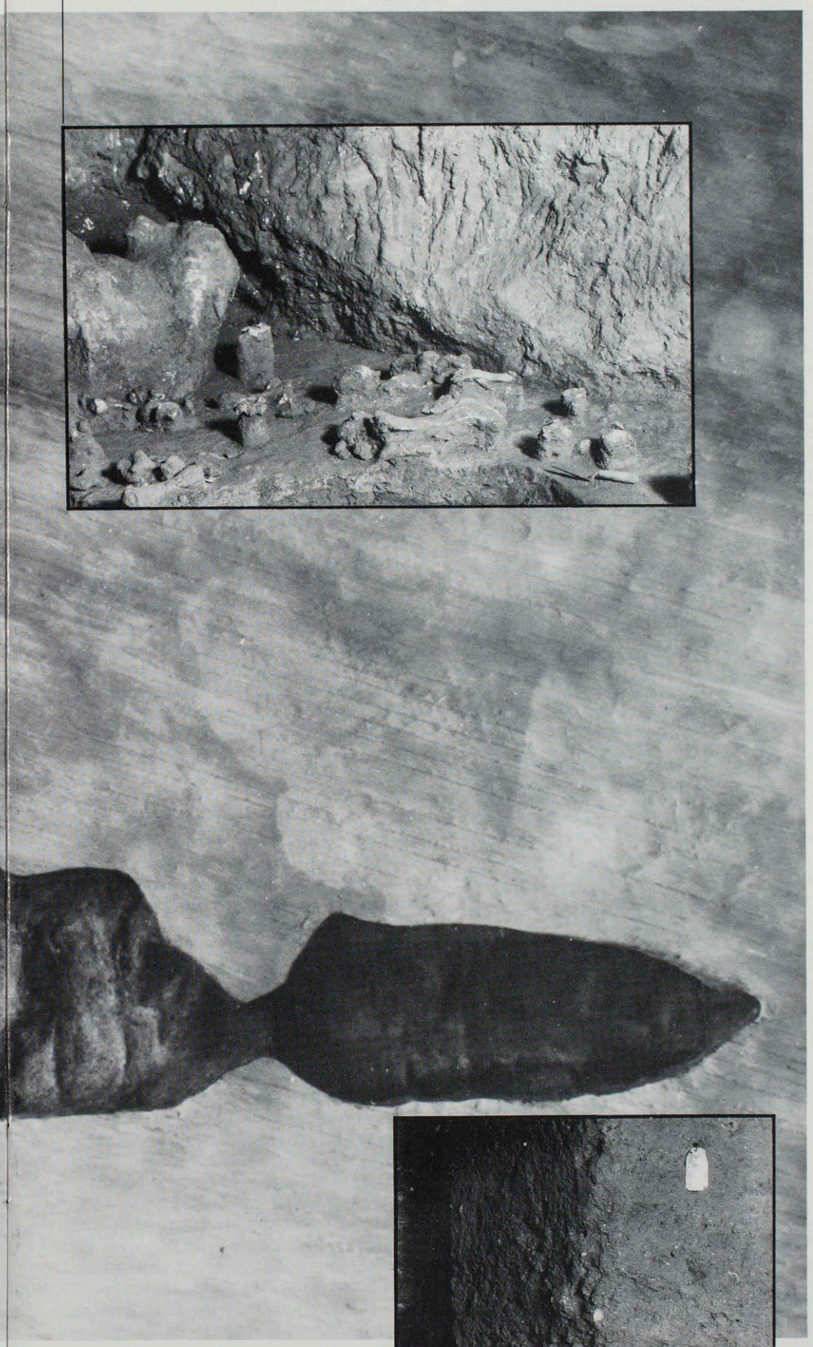
Interior of the upper level of Bishop's Cap Cave, showing ladders and winch-lowered bucket.

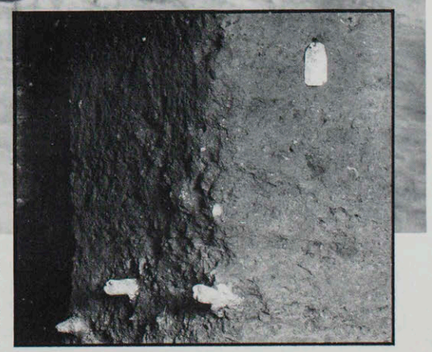




Workers at the camp at the base of Bishop's Cap Peak. From left to right: James W. Lytle, Henry Anson Wylde, Wesley L. Bliss, an unidentified visitor, Roscoe P. Conkling, and three of the local workmen.

Floor of Bishop's Cap Cave with animal bones as excavated (note trowel in lower right-hand corner for scale).





Original stratigraphic column in Bishop's Cap Cave. Remnants of the cave seal can be seen at the top. A tag marks a "find," and several bones are protruding at the lower left.

Times." Perhaps from this, a story appeared in the *Santa Fe New Mexican* on May 13th with the headlines:

NEW MEXICANS LIVED WITH GIANT SLOTH, CAVE BEAR AND CAMEL

Bones Dug up at Bishop's Cap Peak Place Man Definitely in Pleistocene Period

Los Angeles Museum Has Made Epochal Discovery

Conkling seems to have broken into print in the *New York Herald Tribune* on June 16th, and the *Christian Science Monitor* also carried a brief story on the 16th or 17th. After Bryan's article appeared in *Science*, a science news service released a bulletin headed: "ANCIENT MAN IN AMERICA INDICATED BY NEW FIND," and on August 2nd, sensational headlines appeared in several widely distributed newspapers:

FOSSIL FIND SHEDS NEW LIGHT ON PREHISTORIC MAN

Bones Trace Race 150,000 Years Back

Human Skeleton Found Beside Those of Extinct Mammals in New Mexico; Shipped Here

Los Angeles Examiner

FOSSILS CLEAR DOUBT ON PAST

New Mexico Find Links Man with Pleistocene Age

Existence of Species Traced Back 250,000 Years

Museum Director Discloses Import of Discovery

The New York Times

MOST IMPORTANT DISCOVERY IN HISTORY MADE

El Paso Herald

The Science Service had made no claims of age beyond "near the close of the Great Ice Age." The *El Paso Herald* placed the finds at only 25,000 years. However, Bryan, in his letter of August 5th to Bliss and Wylde, cited above, wrote that "as usual [the newspaper reporters] took the liberty of fixing the date of the burial of the man, to suit themselves — this time 250,000 years ago," and to Roscoe Conkling, on August 15th, Bryan wrote: "neither Dr. Stock, Mr. Lytle nor myself were responsible for the 250,000 year statement....I note that your local paper was kind enough to say that it was only a mere 25,000 years, so I regard El Paso as a conservative community."

Back at the cave, not a great deal was happening. Bliss and Wylde had learned of another cave near Picacho, which aroused their interest. In and near the camp, a number of rattlesnakes were killed. Henry Wylde began to make drawings of Bishop's Cap Cave, using coordinates provided by Bliss and equipment borrowed from New Mexico College of Agriculture and Mechanic Arts.

On August 27th, Bliss records in his diary that they sighted the *Graf Zeppelin.*

On the 28th, Bryan, his wife, Conkling, and Mrs. Vear came to visit. There is little doubt that they wished to ensure that Bliss had not irrevocably damaged the cave with his dynamiting. Bryan was reassured and gave Bliss and Wylde permission to excavate the Picacho cave as well. On September 7th, they began work on the new site. This cave produced no human or ancient animal bones, but it did contain numerous artifacts, including many perishables such as matting and sandals. After exhausting the possibilities at Picacho, the camp was closed down, and on September 24th, Bliss and Wylde set out for Los Angeles by motorcycle and sidecar, arriving four days later — a trip that they remember well today.

During the autumn, the museum staff occupied itself with studies of the material and preparations for an exhibition including the construction of a large plaster model of Bishop's Cap Cave based on the drawings that Wylde had made at the cave.

On December 16th, Conkling again wrote Bryan:

> Last Sunday Nicanor and three other boys directed me to a *new* Indian shelter cave, halfway up the West slope of Bishop's Cap peak. The boys have been digging there for a few days and from the material recovered it was evidently the habitation of THE BASKET WEAVER MAN. The fragments of woven work are typical of this culture.
>
> Far back in the interior and at a depth of 48", in a strata of fine ash, were discovered part of a lower jaw and toe bone of a horse, ass, or burro, and fragments of other animals. These are all partially charred.
>
> I am sending these bone fragments to you in the hopes that they can be identified. I have never met with this condition before in an Indian fire pit. It would seem to indicate that horse meat provided an element of their diet.

It was later concluded that the charring was simply a result of the fire being built over the bones. Since today there is little question that the so-called Big Game Hunters did, indeed, eat horse and other Pleistocene mammals, reexamination of this material is indicated. No radiocarbon dates on the cultural objects were ever secured, although a series of dates derived from coprolites and packrat middens fall into the range of 11,330 to 12,520 years ago.

Later, Conkling sent another find from the new cave that greatly excited Stock. It proved to be the partial skull, with horn cores, of a new species of Pleistocene antelope, which Stock subsequently named *Tetrameryx conklingi.*

EL PASO HERALD
JUNE 17, 1930

AIRS

Wedding Solemnized in Bishop's Cave

Mrs. Margaret B. Vear Becomes Bride of Roscoe Conkling

Bishop's caverns formed an age old cathedral for the wedding of Roscoe P. Conkling, archaelogist, to Mrs. Margaret B. Vear which was solemnized yesterday afternoon at 5:30 o'clock by Rev. C. S. Walker, pastor of the Methodist church of Las Cruces.

The wedding took place 50 feet below the ground at the lowest cave level. Yucca blossoms and lighted candles formed an aisle for the wedding party which climbed down a ladder to the marriage place, an altar formed of desert flowers and plants.

Just over the altar, a wedding bell of white flowers was suspended. The chamber selected for the wedding has very beautiful stalactite formation and is one in which Mr. Conkling has made discoveries which scientists say is evidence that man is co-existent with animals of the Pleistocene period.

For the wedding the bride was costumed in an ensemble of blue silk with white accessories and she carried a bouquet of white rosebuds.

In addition to the couple and minister, Judge Albert Fountain, of Mesilla, N. M., and Paul Manning were present.

The bride, who is prominent in musical circles of El Paso is a past president of the El Paso Music Teachers' association and a member of the MacDowell club. She attended Chicago university, the American Conservatory of Music in Chicago, the University of California and Columbia university.

Mr. Conkling, formerly of New York, has been statistician for the American Smelting and Refining company for several years. Mr. Conkling writes fod several publications on archaelogical discoveries.

He and his bride are at home at 4507 Pershing Drive.

* * *

A clipping from the El Paso Herald *of June 17, 1930—part of the LACM file on Bishop's Cap Cave.*

The museum had begun to refer Bishop's Cap as Conkling's Cavern in honor of its most enthusiastic student, and Stock presented a paper on the occurrence of human remains at "Conkling's Cavern" at the meetings of the Pacific Coast Branch of the Paleontologist Society. Dr. Hildegarde Howard, the museum's only full-time paleontologist (Stock was also employed by Cal Tech) was engaged in studies of the bird remains from Bishop's Cap Cave, and she began work on birds from the new cave, now known as "Shelter Cave," as well.

In the summer of 1930, Conkling married Mrs. Margaret Vear, a frequent visitor to Bishop's Cap Cave the previous summer. The wedding was conducted in the cave, and Conkling described it as "the happiest event I believe ever to have taken place in that ancient cavern." Having visited the site, I stand in admiration of the bride's fortitude. Climbing down into that dark cave in one's wedding clothes would require great determination. There is no doubt whatsoever that the new Mrs. Conkling fully shared her husband's enthusiasms.

Intrigued by the discoveries in Shelter Cave, the museum sent another crew into New Mexico. Work at Shelter Cave occupied August and September of 1930, and the collections amassed there, both paleontological and archaeological, were shipped to Los Angeles for study.

In the years that followed, Conkling and Bryan continued to correspond. On April 22nd, 1937, Bryan wrote Conkling: "I...regret that Dr. Stock's report on the Bishop Cap find has been delayed and side-tracked until its significance has to a large extent been lost sight of by workers in his line." On the 29th of July, 1938, Bryan replied to an inquiry from Brazil:

> The extensive material excavated by this institution from Bishop Cap cavern in New Mexico has not as yet received adequate study. A short paper on the bird material was published by the Museum. Dr. Chester Stock has [been preparing] a paper on the mammalian material for several years, but owing to the depression the matter has not come into publishable form. The human material has not been studied at all.

There the situation rested until 1946, when Dr. T. Dale Stewart, Curator of Physical Anthropology at the Smithsonian, wrote Stock, who was by that time affiliated almost entirely with the California Institute of Technology, requesting permission to study the human remains from Bishop's Cap Cave. Stock was willing to arrange the loan, but he died before he was able to do so. It was not until 1951 that the human skeletal remains were shipped to Stewart. The study resulted in two publications. One, a brief notice entitled, "Preliminary Observations on the Human Skeletal Re-

mains from Conkling Cavern, New Mexico," appeared in the *American Journal of Physical Anthropology* in late 1951. Here Stewart remarks, "My conclusion is that these skulls do not differ significantly from those of modern Indians." His second publication, "The Fluorine Content of Associated Human and Extinct Animal Bones from the Conkling Cavern, New Mexico," appeared in *Science* in 1952.

Fluorine analysis, the method that ultimately proved that "Piltdown Man" was a hoax, has frequently been used to test the contemporaneity of bones from archaeological sites; fluorine content does not establish the age of a specimen except in a relative way. The quantity of fluorine present in bone is dependent on two factors, the amount ingested by the animal during its lifetime and the amount absorbed from the ground water in which the bone was deposited. The fluorine content tests performed on the Bishop's Cap material were, unfortunately, inconclusive, owing to the extreme ranges present. However, all human bone tested was higher in fluorine than all animal bone, and, for the most part, the human bone from the lowest levels tested higher than that from the upper levels.

Stewart indicated that, on the basis of the tests, "we cannot rule out the implications from the juxtaposition of the bones that all these forms lived contemporaneously." He suggested that the variation might be due to the dryness of the area, the possibility that "men had access to drinking water rich in fluorine, whereas the animals did not," or "that the thinner cortex of the human bones was a factor in determining the rate of fixation of fluorine after death." A further problem was that the fluorine content was lower than the usual range for Pleistocene bone. However, fluorine accumulation in bone in limestone-cave deposits such as Bishop's Cap, tends to be lower than in bones from other types of deposits.

Interest in the cave again flagged until 1964, when George Agogino of the Paleo-Indian Institute, Easern New Mexico State University, and Leslie Davis, representing the El Paso Archaeological Society, returned to the cave. Agogino intended to publish on the cave and borrowed both the human skeletal material and the soil samples that had been taken at the site. For the first time, several radiocarbon assays were made, but again, results were inconclusive. Like the fluorine-content analysis, the radiocarbon tests raised more questions than they answered.

Two tests were made on collagen from human femurs. One gave a date of 1590 ± 80 years B.P., or *ca.* A.D. 361. The second, produced a date of 5320 ± 120 years B.P., or about 3369 B.C. While either date could conceivably apply to the human remains, the first is much too recent for the associated animals. The second appears to be about 5000 years too recent for the presence of Late Pleistocene mammals, although some scientists feel that both sloth and horse could have survived for some time after the extinction of the larger Pleistocene forms. Horse and camel fossils have not, however, been found in post-Pleistocene strata.

Agogino has not yet published on his excavations of the cave. Leslie Davis, however, did prepare a paper, "Bishop Cap Cave," based on both their 1964 trip and what information he could find in print, in 1969, but it was not widely distributed.

If interest in Bishop's Cap Cave had languished in Los Angeles, such was not the case in the Las Cruces/El Paso area. Even before I took up my post as Director of the University Museum at New Mexico State University in Las Cruces, I was asked about the whereabouts of the Bishop's Cap material. Not long after I arrived in Las Cruces, I attended my first Doña Ana County Archaeological Society meeting, only to hear once more about the site from Les Davis. The odd coincidences persisted when Craig Black, with whom I had worked closely at the Texas Tech University Museum, accepted the directorship of the Los Angeles County Museum of Natural History, where the materials from Bishop's Cap Cave actually resided. Since local interest in the site still ran high, I decided to investigate further.

On a preliminary trip to Los Angeles, with the cooperation of the Vertebrate Paleontology staff, I found more than 300 pieces of correspondence, field reports, and photographs in the files of the division, in addition to the collections themselves. In November 1982, to my great delight, we were able to assemble Dr. Wesley Bliss, now an anthropologist and geologist, Dr. Hildegarde Howard, Emeritus Chief Curator of Science, and her husband, Henry Anson Wylde, now retired from his position as Chief of Exhibitions at LACM, to discuss the site in which they had all been so deeply involved. It was the first meeting of "the boys," Bliss and Wylde, in 53 years. We taped their reminiscences, and Dr. Bliss made his field diary available, providing me with many anecdotes and a rare sense of what it was like to be in the field in New Mexico in 1929.

In May 1983, I visited the cave, which is now inside the Doña Ana Firing Range at Fort Bliss, accompanied by archaeologists Steadman Upham of NMSU and Glen Degarmo of the Fort Bliss staff. Using Davis's coordinates, we found Bishop's Cap Cave with no difficulty, but, having no ladder or ropes, we did not descend into the cave. Locating Shelter Cave, knowing only that it was on the west slope of Bishop's Cap but with a 1930 snapshot of the shelter, was only a bit more difficult. It proved to be more than halfway up the slope, a steep climb that must have been arduous on a daily basis for both the museum's crew and the original inhabitants.

Why did Bishop's Cap Cave go so long almost unnoted by anthropologists? There appear to be a number of reasons. The first, already mentioned, was the prevailing contemporary thought about early humans in the Americas. Bliss recently told me that Stock, as a graduate student at Berkeley, had been warned to be cautious about things that dealt with "early man." Stock may, indeed, have had a manuscript or manuscripts in progress on the mammal and human remains from the site, as Bryan suggested, but we will never know. After his death, his secretary reportedly burned his files, regarding them as "personal." Second, the removal of the materials from New Mexico almost immediately after their discovery probably produced a kind of "out-of-sight, out-of-mind" situation among local archaeologists. There was also considerable confusion locally about where the material actually resided in Los Angeles. Some thought that it was at the LACM and others at the Museum of the Southwest. Furthermore, when locals corresponded with the LACM, they invariably addressed the Archaeology Section and inquired about Bishop's Cap Cave. The material was, as noted, in the Vertebrate Paleontology Section and filed under Conkling's Cavern. The confusion about names for the site (it was also sometimes known as Beasley Cave) obviously did not simplify matters.

Although more instances of purportedly early remains have come to light since the 1920s, they are still extraordinarily rare, and thus Bishop's Cap is still of interest. Writing in 1957, Marie Wormington said of the cave: "Human skeletal remains reportedly found in deep deposits containing bones of extinct animals in a cave of Bishop's Cap Peak in southwestern New Mexico... *may be important*, but no adequate report has been published [italics mine]."

While it is unquestionably difficult to interpret a site 54 years after the fact, and while we may never be entirely certain that our interpretations are correct, I am convinced that full publication of what is known about both Bishop's Cap and Shelter Caves is completely worthwhile. The mysteries still surrounding these cave materials are indications of the problems that are waiting to be solved in many older museum collections.

Dr. King is Director of The University Museum of New Mexico State University. Although her research focuses on prehistoric textiles, she is currently assisting in the preparation of a book, and an exhibit for The University Museum, on the finds at Bishop's Cap Cave.

The Lincoln Heights Whale

by GIOVANNI R. BUSSINO
and LAWRENCE G. BARNES

One of the oldest permanent exhibits in the Natural History Museum is the 8-foot-long fossil skull and jaws of a Miocene baleen whale, *Mixocetus elysius*, commonly known as "The Lincoln Heights Whale." The discovery site of this venerable object was in the hilly Lincoln Heights district, northeast of downtown Los Angeles. Fortunately for us, the dark brown fossil has survived threats to its existence ranging from having been nearly weathered away into topsoil before it was excavated, to being climbed and walked upon by misguided young museum visitors. Except for a few years in the mid-1970s, these huge bones have rested on their sturdy steel and wood base in the museum's east wing from the mid-1930s to the present time.

Museum records indicate that the fossil dates from the late Miocene Epoch (meaning that the animal swam the seas about 10 to 11 million years ago), and that in 1934 our specimen was used as the basis for the description of a new species named *Mixocetus elysius*. But what were the circumstances surrounding the discovery and excavation of this fossil, one of the largest ever obtained by the museum? Who was involved in its collection, preparation, and study? What happened to the rest of the skeleton? What do we know about the environment in which our fossil once lived? In an effort to answer these and other such questions, we have researched and written the story of the Lincoln Heights Whale. To illustrate and highlight our findings, we have included some photographs, most of which are from the museum files.

Throughout most of past geologic time, much of southern California, including the Los Angeles Basin, lay under the waters of the Pacific Ocean. When our *Mixocetus elysius* fossil was a living whale, the Santa Monica Mountains, the Palos Verdes Hills, the San Jose Hills, and many other hilly regions in the Los Angeles area were flat sea bottom. The shoreline ran through locations as far inland as Newhall, Sunland-Tujunga, San Dimas, and Chino. During all this time, fine-grained sediments were washing down from the land and out into the basin, forming thick deposits of mud and sand on the sea floor.

The species *Mixocetus elysius* must have been one of the largest members of the marine fauna that thrived along the southern California coast about 10 to 11 million years ago. Approximately 32 feet long, it had a body size much greater than that of most ancient baleen whales. Other contemporary cetaceans in these waters included at least two kinds of sperm whales, beaked whales, relatives of the Arctic belugas, the earliest modern dolphins and their cousins the porpoises, as well as a variety of extinct dolphin groups. Besides these cetaceans, there flourished a mixture of other exotic and more familiar marine creatures, including the last of the desmostylians (extinct marine analogs of the hippopotamus), the earliest fur seals, several species of walruses — some without tusks, the earliest relatives of the Steller's sea cow, huge leatherback turtles, petrels, murres, shearwaters, gannets, boobies, cormorants, giant bony toothed birds — *Osteodontornis*, and small flightless auks. Also living in the sea at this time were 40-foot-long great white sharks, mako and tiger sharks, bat rays, saber-toothed salmon, herring, mackerel, and sardines. Individuals of all these species died from time to time and sank to the ocean floor where many of them were to be preserved in the soft ooze.

Our specimen of *Mixocetus elysius* was no exception. We do not know why the animal died. Its bones show no evidence of disease or shark bites, both of which have been found on bones of some other fossil cetaceans. It was a mature individual, probably at least ten to twenty years old. Apparently the carcass of the mammal bloated and drifted for a long time, for it sank, belly up, to the bottom of the sea. There it lay, as silt continued to wash into the ocean, settling over and around the gigantic mass.

As the sediments hardened and turned into rocks with the passage of time, the remains of many ancient sea creatures, including the bones of our whale, became fossilized. Later, the southern California coastal area underwent dramatic geological changes. Most of the Los Angeles Basin was uplifted by geologic phenomena, which pushed up the marine sediments to create the various mountains and hills in the Los Angeles area. The parts of the marine rocks that date from about 10 to 11 million years ago and form the Santa Monica Mountains and the other hills in and around Los Angeles have been given the name Modelo Formation. The same formation occurs in Lincoln Heights where it is called the Elysian Park Sandstone Member of the Modelo Formation —named for typical outcrops in Elysian Park, 2 miles to the west of the discovery area.

It was in this particular rock unit that our fossil remained embedded and undetected, until January 22, 1931, when a

Page 17, center, left: Mr. F. W. Maley stands in the pit dug in Mrs. L. W. Blevins's hillside property off Lincoln Park Avenue on February 3, 1931. Mr. Maley is behind the exposed skull of the whale, which is lying upside down with its snout pointing away from the camera. In Mr. Maley's hands is a lumbar vertebra like the one he first uncovered while digging a trench for an irrigation system. The tilted, well-bedded layers of shale comprising the Modelo Formation are clearly visible in the wall of the pit. Photo by H. William Menke.

Page 17, center, right: A derrick, fitted with block and tackle, was built over the pit to hoist the plaster-encased skull to the surface. Cross braces of lumber can be seen on the plaster jacket. The people in this photograph unfortunately have not been identified, although the man in the vest might be Mr. Maley. The date is early February 1931. Photo by J. W. Lytle.

Page 17, bottom: Side view of the skull, still cradled by the plaster and burlap jacket applied in the field. When the whale fossil was brought to the museum, Henry Wylde was assigned the task of cleaning it. At the time this photograph was taken, about April 1931, Wylde had finished cleaning the top surface. In the background are the then vine-covered east wing of the museum and a dormitory at USC across Exposition Blvd. Photo by H. William Menke.

TWO MONTHS AT TWO GREAT MUSEUMS

NATURAL HISTORY MUSEUM
OF LOS ANGELES COUNTY, EXPOSITION PARK
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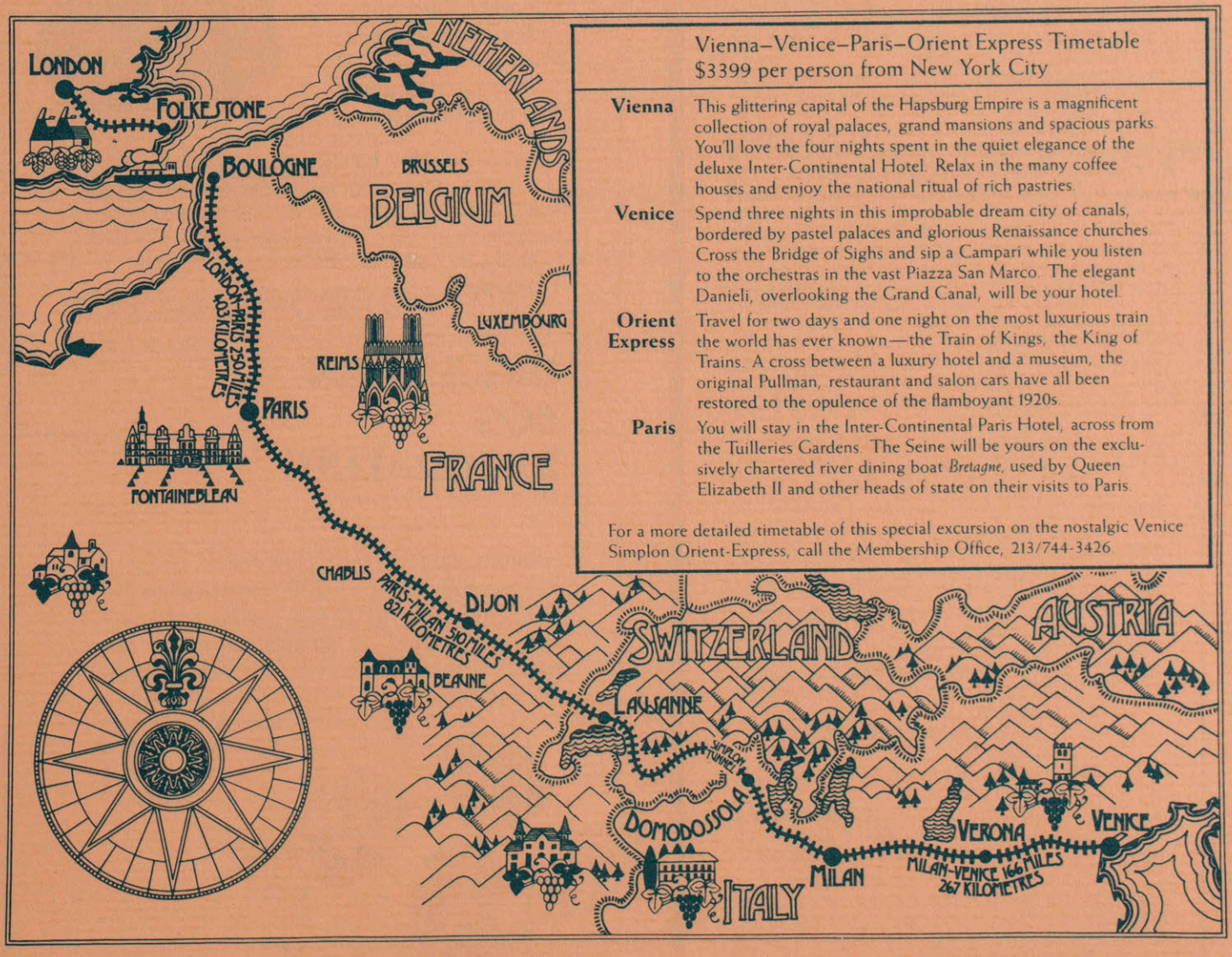
MARCH/ APRIL 1984

CALENDAR OF EVENTS

THE ORIENT EXPRESS ADVENTURE

AN EXCLUSIVE TWO-WEEK HOLIDAY, JUNE 22 TO JULY 5, 1984



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Orient Express Travel for two days and one night on the most luxurious train the world has ever known—the Train of Kings, the King of Trains. A cross between a luxury hotel and a museum, the original Pullman, restaurant and salon cars have all been restored to the opulence of the flamboyant 1920s.

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For a more detailed timetable of this special excursion on the nostalgic Venice Simplon Orient-Express, call the Membership Office, 213/744-3426.

EDUCATION DIVISION SPRING WORKSHOPS

The Education Division is once again offering a popular series of craft workshops for adults at the Natural History Museum.

PINE NEEDLE BASKETRY

JUDY MULFORD, Instructor

Saturday, March 10,
or Saturday, March 31,
9 a.m. to 4 p.m.
$20 Museum Members,
$25 Non-Members

Learn basic coiled basketry techniques in this one-day workshop for beginning basketmakers. Utilizing pine needles as a foundation and pattern material, you will create decorative and functional baskets. All materials will be provided. Limit 10 people.

UKRAINIAN EGG DECORATING

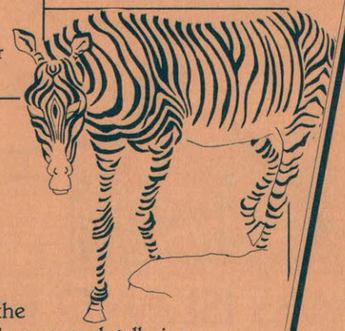
PAT WOOLLEY, Instructor

Saturday, April 7, 9 a.m. to 12 noon.
$15 Museum Members, $20 Non-Members

Noted folk artist Pat Woolley will teach this workshop on "pysanky," the Ukrainian art of batik-dying eggs. These lacquered eggs with their geometric designs and glowing colors are recognized as jewels among Easter eggs. All materials will be provided. Limit 15 people.

WILDLIFE DRAWING

WALTER O'NEILL, Instructor



Four Wednesday evenings,
7 p.m. to 9 p.m.
May 2 through May 23
$35 Museum Members,
$40 Non-Members

Join us for an exotic sketching safari through the Natural History Museum's mammal galleries where you will learn to draw African and Asian animals in their native habitats. Walter O'Neill, Museum Educator at the Getty Museum and formerly with the American Museum of Natural History, will teach you elementary drawing with charcoal and pencil. Materials provided. Limit 25 people.

FOSSILS & FUR: MAMMALS OF TODAY AND YESTERDAY

A Workshop for Grades 4 through 6

April 28, Los Angeles Zoo
May 12, Page Museum
9:00 a.m. to 12:30 p.m.

Forty thousand years ago, large mammals such as the mammoth, the ground sloth, and the short-faced bear made their home in the Los Angeles Basin. By 7,000 years ago these animals had disappeared. Why did these animals become extinct? What can their fossils tell us? Who are their modern relatives and where do they live?

These and other questions will be explored in this second annual two-day workshop offered by the Natural History Museum and the Greater Los Angeles Zoo Association. The class will include behind-the-scenes tours, hands-on fossil workshops, and rides on an elephant and a camel. Enrollment is limited to 20 students. Cost $20.

Please send the form below and your check or credit card information with a stamped, self-addressed envelope to Joan Grasty, Education Division, Natural History Museum, 900 Exposition Boulevard, Los Angeles, CA 90007.

For further information, please call the Education Division, 213/744-3341.

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- ☐ PINE NEEDLE BASKETRY, Saturday, March 31
  - ☐ Museum Member, $20 ☐ Non-Member, $25
- ☐ UKRAINIAN EGG DECORATING, Saturday, April 7
  - ☐ Museum Member, $15 ☐ Non-Member, $20
- ☐ WILDLIFE DRAWING, Wednesday Evenings, May 2 through May 23
  - ☐ Museum Member, $35 ☐ Non-Member, $40
- ☐ YOUTH WORKSHOP, Two Saturdays, April 28 and May 12
  - ☐ Museum Members Only, $20
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OPENING EXHIBITS

Aymara Weavings: Ceremonial Textiles of Colonial and 19th Century Bolivia. May 15, 1984 through June 24, 1984

CONTINUING EXHIBITS

Celebrations of the Insect Form: Watercolors by Ray Bingham. Through March 18, 1984.

Laetoli: Footprints in the Ashes of Time. Through March 4, 1984.

Mushrooms Up and Down Los Angeles. Through September 2, 1984.

The Gregorian Calendar. Through September 30, 1984.

California Condors. Through October 28, 1984.

The Natural History Museum, located at 900 Exposition Boulevard, Exposition Park, Los Angeles, California 90007, is open from 10 a.m. until 5 p.m., Tuesday through Sunday. The museum is closed Mondays, Thanksgiving, Christmas, and New Year's Day. Admission is free to Museum Members. For further information, please call 213/744-3414.

The Page Museum of La Brea Discoveries, located at 5801 Wilshire Boulevard, Hancock Park, Los Angeles, California 90036, is open from 10 a.m. until 5 p.m., Tuesday through Sunday. The museum is closed Mondays, Thanksgiving, Christmas, and New Year's Day. Admission is free to Museum Members. For further information, please call 213/857-6311.

NOTE FOR WEEKEND VISITORS

There is a $5.00 fee for parking in the Natural History Museum lot on game days at the Coliseum. If you would like to check on the game schedule for 1984, please call Museum Security, 213/744-3414.

EARTHWATCH

CHRISTMAS ISLAND BIRDS

Join Dr. Ralph Schreiber and Betty Anne Schreiber of the Natural History Museum in an Earthwatch expedition to Christmas Island. In November of 1982, eighteen species of seabirds that nest regularly on Christmas Island abandoned their nestings. Virtually all died. Was the recent El Niño the cause? Participants will observe nests daily and band birds at night to monitor the bird population. This timely project guarantees hands-on experience among varied seabird colonies on the largest coral atoll in the world.

Research will be conducted from March 22 to April 2, 1984; July 5 to July 23, 1984; October 25 to November 5, 1984; and January 17 to February 4, 1985. Cost of participation is $1495 for the March/April and October/November research sessions; and $1895 for the July and January/February 1985 sessions. For further information, please call the Schreibers at 213/744-3366.

ADVENTURES IN ANTHROPOLOGY

THE SOUTHWEST

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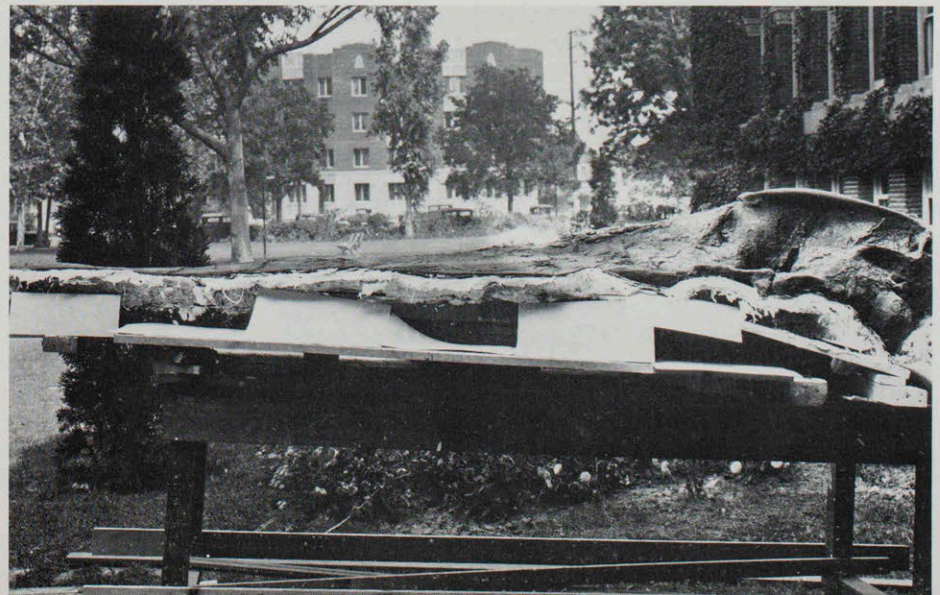
plumber, Mr. F.W. Maley, came upon one of its large vertebrae while digging a trench for an orchard irrigation system on land belonging to Mrs. L.W. Blevins. The fossil was discovered on a slope near Lincoln Park Avenue in Happy Valley (a section of Lincoln Heights), 500 feet above sea level and about 20 miles inland from the ocean. The steep hillside leads up to "Flat Top," a prominent landmark that now sports a growth of radio transmission towers.

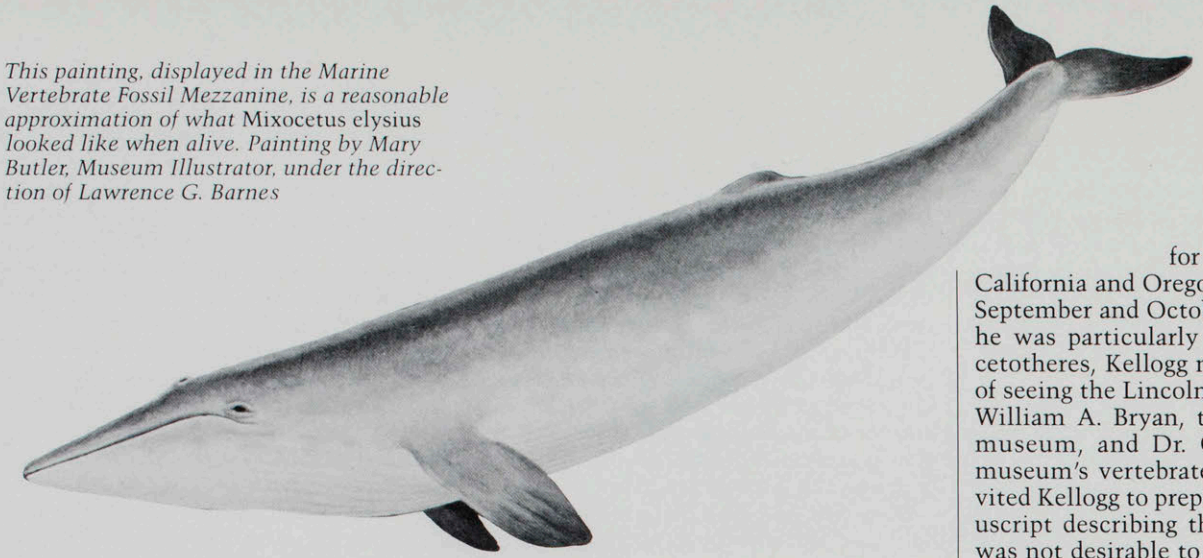
Realizing the importance of his discovery, Mr. Maley immediately telephoned the museum and brought in the 18-pound vertebra, which was promptly identified by the assistant vertebrate paleontologist, Mr. J.W. Lytle, as a lumbar vertebra of an extinct whale. Two days later, with the permission of Mrs. Blevins, a museum excavation began at the site. Mr. Lytle, assisted by his staff, Mr. William Strong (field man) and Miss Lydia Bowen and Mr. Henry Wylde (laboratory technicians), performed the laborious task of removing the overlying shale. After a little more than two weeks, the remaining bones of the whale were uncovered and carefully prepared for removal to the museum. Only after the long, straight lower jaws were unearthed and found to show no indication of teeth was it realized that the fossil was a baleen and not a toothed whale.

Interviewed by the press at the excavation site, Mr. Maley reportedly said: "I was digging and came on a rock that looked like a vertebra. I dug around a little and saw some more and knew I had found something. I have visited the museum on many occasions and I knew I had something. So I called them up and there it is." Museum officials, who were also present, were said to have expressed great delight over the remarkable find, complimenting Mr. Maley for his keenness and good judgment.

Of the original skeleton, there remained twenty-two vertebrae (five cervicals, twelve thoracics, and five lumbars), the left shoulder blade, the skull, and both lower jaws. The tail section had long since weathered away into the topsoil, and some of the ribs and flipper



bones had evidently been scattered by currents prior to fossilization. There was no trace of baleen,- those thin, bristly plates that hang from the upper jaws of such whales and are used to capture food, because such fiberous epidermal material is rarely fossilized. After the bones had been encased in protective jackets of plaster and burlap, they were hauled up to level ground to be loaded onto a truck. The skull presented an especially challenging problem in that it lay in the deepest part of the pit (about 9 feet down) and, with its plaster jacket, was some 8 feet long and weighed about 3,000 pounds. A four-legged derrick, fitted with block and tackle, had to be set up to lift the bulky mass out of the excavation. It was then



This painting, displayed in the Marine Vertebrate Fossil Mezzanine, is a reasonable approximation of what Mixocetus elysius *looked like when alive. Painting by Mary Butler, Museum Illustrator, under the direction of Lawrence G. Barnes*

dragged up the slope on a skid and hoisted onto a truck.

Although accounts of the fossil appeared in local newspapers one week after the initial discovery, the museum workers allegedly tried to keep a low profile during the entire dig because the bones had to be left unguarded at night. Stories of the discovery in the *Los Angeles Examiner*, the *Los Angeles Times*, the *Los Angeles Evening Herald*, the *Glendale News-Press* (January 29, 1931), and in the *Lincoln Heights Bulletin-News* (January 29 and February 12) contained several imprecise or erroneous conjectures. It was reported, for example, that the fossil was "presumably the skeleton of a beaked whale" (a family of toothed whales called Ziphiidae), that the mammal had probably existed in the Pliocene or Miocene Epoch, and that it was therefore more than 2.5 million years old. In reality, as was later made public and as we have pointed out above, the fossil is that of an ancient baleen whale (family Cetotheriidae) and actually had lived about 10 to 11 million years ago, that is, in the latter part of the Miocene Epoch, which extended from about 5 to 22 million years ago.

The Lincoln Heights Whale was the first significant whale fossil collected by our museum and was more complete than almost any previous such find from the Pacific region. Accordingly, it was given high priority in the Vertebrate Paleontology Laboratory, where Henry Wylde began the task of cleaning and restoring the skull and jaws. Because the fossil had lain close to the surface in blocky shale, much of it had weathered and cracked into small sections. Even after the skull was hardened with glue and shellac, it could not support its own weight because of the fractures. The resourceful Wylde then fashioned two plaster and burlap holders to conform to the top and bottom contours of the massive bones. Using the holders like a gigantic clamshell, he was able to turn the specimen over at will for further cleaning and for photographing. Mr. Wylde spent several days restoring the lower jaws, which were crushed and fractured in several places when found, to their original shapes. Much of this preparatory work was completed by April of 1931.

Wylde finished the work by constructing a framework of steel plates, straps, and rods to support the ponderous skull. With the skull resting upside down in the temporary holder, Wylde made the necessary measurements and then cut the steel rods individually for correct mounting to threaded flanges on a wooden platform. To elevate and support the lower jaws beneath the skull, he used a series of forked rods, which he mounted on both sides of the platform.

The museum photographer, Mr. H. William Menke, recorded Wylde's progress in a series of photographs that show the skull in various stages of cleaning. Wylde relates that Menke wanted to make 8- by 10-inch negatives to capture even the slightest detail but lacked a camera large enough to accommodate the large sheet film. Menke therefore improvised, mounting a lens from a smaller camera onto a large hand-made box with bellows. The camera had to be mounted on a scaffold many feet above the skull. Because all of the photographs were to be taken out-of-doors, a linen sheet was hung up as a sun screen to provide softer, indirect lighting. For each photography session, the specimen was wheeled out of the building through the Education Lending Service exit to the current site of the staff parking lot.

The existence of the unique specimen soon caught the interest of Dr. Remington Kellogg, then a recent graduate of the University of California at Berkeley, who had written a history of the evolution of whales for his doctoral dissertation. After working in Washington, D.C., for several years in varying capacities for the Carnegie Institution, the U.S. Bureau of Biological Survey, and the U.S. National Museum (Smithsonian Institution), the young paleontologist had already started to make a name for himself. He visited California and Oregon on a study trip in September and October in 1932. Because he was particularly interested in fossil cetotheres, Kellogg made a special point of seeing the Lincoln Heights Whale. Dr. William A. Bryan, then director of the museum, and Dr. Chester Stock, the museum's vertebrate paleontologist, invited Kellogg to prepare a scientific manuscript describing the fossil. Because it was not desirable to transport the specimen to our nation's capital, Kellogg spent several days at our museum studying and measuring each bone and making detailed notes. Mr. Menke's excellent photographs then became useful, and three of these were later printed together as a plate in Kellogg's report, which appeared in 1934. The line drawings of the skull, also published in the report, were made from these same photographs by Mr. Sydney Prentice, a well-known scientific illustrator. The precision of these drawings is a tribute not only to the illustrator's skill but also to Mr. Menke's improvised 8- by 10-inch camera and his indirect lighting technique.

To determine the age of the fossil, Kellogg availed himself of the expertise of Dr. William S.W. Kew and Mr. H.L. Driver, who inspected the locality where the cetothere was found. The two geologists confirmed that the source rock was the Late Miocene Modelo Formation and represented the oldest rocks exposed in Los Angeles east of the Santa Monica Mountains. They also analyzed various samples of shale that they collected in the vicinity of the discovery site and found them to contain characteristic microscopic Late Miocene fossil marine protozoans (foraminifera), which further confirmed the age of the formation and consequently of the whale fossil itself.

The 21-page scientific paper that Kellogg wrote appeared on January 10, 1934, in the Carnegie Institution of Washington's Publication No. 447, *Contributions to Paleontology*. It is there that the name *Mixocetus elysius* first appears. The genus name coined by Kellogg, *Mixocetus*, suggests a cetacean with a mixture of characters found in various other groups of baleen (or whalebone) whales. The species name that he chose, *elysius*, alludes to the whale's discovery in the Elysian Park Sandstone Member of the Modelo Formation. In his publication, Kellogg was basing these new names solely on our specimen. In fifty years of subsequent collecting, hundreds of Miocene whale fossils have been discovered throughout the North Pacific, but no other specimen has yet been rec-

ognized as belonging to this same species. Moreover, the Lincoln Heights Whale is still the only fossil whale in our museum that has been used in the designation of a new species name.

Exhibited in the museum's Hall of California Fossils, near the skulls of two other whale fossils, *Mixocetus elysius* has continued to enchant the public over the years, especially because of its considerable age and size. Because the other bones of the skeleton are quite fragile, and many are imperfectly fossilized, a decision was made early on not to display them with the skull and jaws but to place them in storage to await further restoration and study. One may gain an impression of this animal's probable skeletal structure, however, by viewing a skeleton of a modern fin whale displayed in the museum's Hall of Evolving Life.

A number of questions concerning the fossil whale still beg for answers. What was the geographic distribution of the species? What were its migration routes, if any? What was its ancestry? What were its life habits? Why did the species become extinct? The study of fossil whales, still in its relative infancy, has not yet found answers to such questions. In point of fact, only in the past few decades has man even begun to document the movements and life histories of some of the living whale species. Our museum has continued to actively support field work and research on fossil whales and is now a recognized world center for such endeavors. As new fossils continue to be found and studied by staff and associates, we will no doubt learn a great deal more, not only about our Lincoln Heights Whale, but also about the many other extinct leviathans that once frequented our shores.

Dr. Giovanni R. Bussino of Burbank, a member of the Museum Alliance and of the American Cetacean Society, is a free-lance writer whose articles have appeared in European and American journals. Because he was born and raised a short distance from the discovery site of the Lincoln Heights Whale, he became especially interested in the history of this fossil. He was prompted to write the present article as a service both to the friends and visitors of the Museum, and to the many residents of the area where he spent his early years.

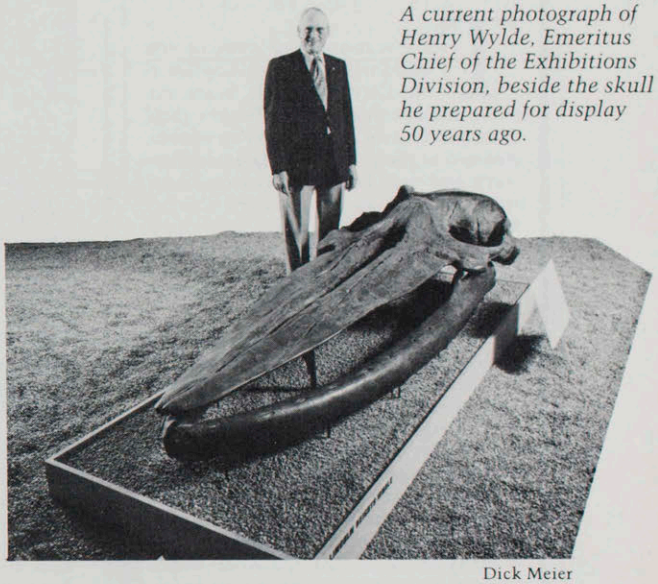
Dr. Lawrence G. Barnes is Curator of Vertebrate Paleontology at the Natural History Museum and is charged with the care of the fossil marine mammals. He has written scientific and popular articles and book chapters on fossil cetaceans, sea lions and other marine vertebrates. He arranged the re-installation of the Lincoln Heights Whale exhibit in the Museum's California Fossil Hall and is presently studying the specimen in relation to other fossil whales.

Notes on the Collectors and Researchers

William Alanson Bryan, *an ornithologist and zoologist, became Director of the Los Angeles County Museum in 1921. He had previously served as curator at the Bishop Museum of Ethnology and Natural History of Honolulu and as professor of zoology and geology at the University of Hawaii; he had also traveled extensively in North America and Europe studying museum administration. During his eighteen years as Director, the facilities, staff, and collections of the Los Angeles County Museum grew significantly. Mr. Bryan resigned from County service in 1939 and died on June 18, 1942.*

James W. Lytle *began his career at the museum in 1913, initially working in the field excavating fossils from the asphalt deposits at Rancho La Brea. During this epochal era in the museum's history, he developed a system, using hydrocarbons, to clean the asphalt from the bones. He also sorted the greater part of this huge collection into the various categories of the mammals and set up the project of cataloging their skeletal parts. He had been ill while some of the Bishop's Cap Cave field work was being done. He died on June 18, 1931, less than 6 months after the Lincoln Heights fossil whale was collected.*

Henry Anson Wylde *came to the museum in 1924 and worked in the Vertebrate Paleontology Department as a preparator until 1939. In this capacity he prepared an exhibit of the fossils from Bishop's Cap Cave, including a scale model of the cave. In 1939 he was awarded a Rockefeller Foundation Grant to study European museums. Upon his return he became Chief of the Exhibitions Division and remained in that position until he retired in 1967.*



A current photograph of Henry Wylde, Emeritus Chief of the Exhibitions Division, beside the skull he prepared for display 50 years ago.

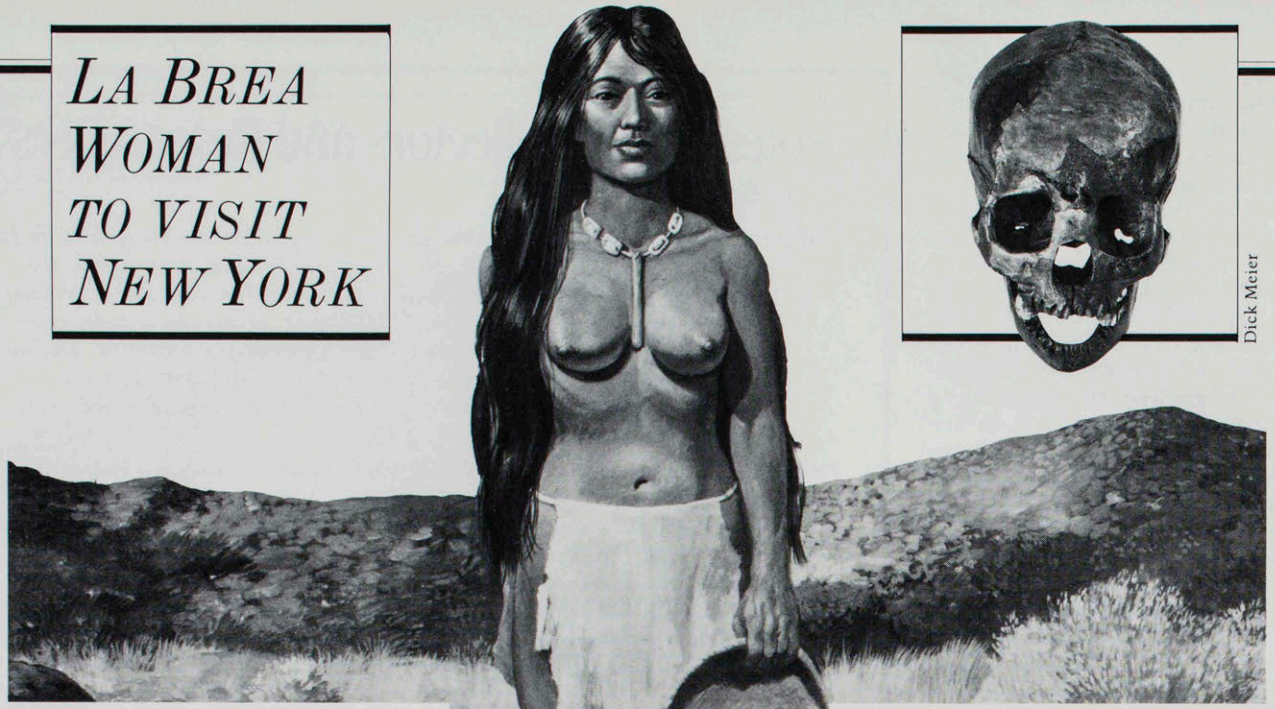
Dick Meier

Dr. Hildegarde Howard, *who is married to Henry Wylde, described the bird remains from Bishop's Cap Cave in 1931 and (with Dr. Alden H. Miller of the University of California) in 1933. In 1951 she became Chief of the Science Division, retiring in 1961. As Chief Curator Emeritus, she continues to study and describe California's fossil marine birds that were contemporaries of the Lincoln Heights fossil whale species.*

Remington Kellogg, *who described the fossil whale specimen, went on to become Director of the U.S. National Museum of Natural History, Assistant Secretary of the Smithsonian Institution, and the U.S. representative to the International Whaling Commission. An energetic researcher, he published over 175 articles, many of which were on fossil cetaceans. He died in 1969.*

The man who brought the Bishop's Cap Cave material to the attention of the museum staff, **Roscoe Platt Conkling,** *was descended from a brother of the New York Senator and one-time presidential hopeful, Roscoe Conkling. As a young man, he had studied music with Anton Dvorak and painting with Frederick Church—his artistic talents are clear in his sketches of the material from Bishop's Cap Cave. He apparently had a particular fondness for caves, for not only was his second marriage solemnized in one, but he once conducted Haydn's Creation in the underground amphitheater of Carlsbad Caverns. Conkling died in 1971; a newspaper clipping of his obituary was one of the last papers added to the Natural History Museum's file on "Conkling's Cavern."*

La Brea Woman to visit New York



Dick Meier

Illustration by John Dawson

This summer the eyes of the world will be on Los Angeles as the City of Angels hosts the pomp and ceremony of the Twenty-third Olympic Games. Some wary residents, alarmed at the prospect of jammed freeways and vast hordes of visitors, have made plans to vacate southern California for the duration of the festivities. One of Los Angeles's oldest inhabitants, La Brea Woman, will also be leaving the city, though for an entirely different reason.

Drs. Ian Tattersall and Eric Delson of the American Museum of Natural History have arranged a major international symposium in New York at the beginning of April. Entitled "Ancestors," the symposium will provide an unusual forum for the discussion of the latest evidence for the ancestry and evolution of man. The innovative feature of this symposium will be the bringing together of many of the original fossils on which our present understanding of human origins are based. Participating scientists will have a week to study these fossil specimens, many of which have never previously been displayed outside their countries of origin, before taking part in a week-long discussion of different aspects of paleoanthropology. The fossil specimens will then be placed on exhibit at the American Museum for the rest of the summer. Scheduled for this exhibit are many specimens from Africa, Asia, Europe, Australia, and South America. La Brea Woman, from the Rancho La Brea deposits in Hancock Park, will be North America's representative at this "ancient family reunion."

Dated at about 9000 years before present, La Brea Woman is not the oldest human fossil from North America but is one of the more complete and better preserved specimens. The partial skeleton includes the skull and many of the arm and leg bones. These remains belonged to a fully mature female (18 to 25 years old) who stood about 5 feet 2 inches tall. The structure of the pelvis indicates that she had given birth to at least one child.

The skull of La Brea Woman was found in several pieces, the bones of the braincase being separated from those of the facial region. Portions of the skull had been fractured. A few of her teeth had been lost before death; those that still remain are somewhat worn and suggest that stone-ground meal formed part of her diet.

Several theories have been suggested to explain the occurrence of this human skeleton in the Rancho La Brea deposits. Extensive damage to the sinus areas within the skull was once interpreted as the effects of severe sinus infection. Delirious from this infection, it has been proposed, La Brea Woman inadvertently wandered into a pool of asphalt and there became trapped like so many other of the Rancho La Brea fossils. More recent examination of this evidence suggests that the damage to fragile sinuses was caused by the abrasive action of the asphalt matrix *after* La Brea Woman died.

Analysis of the type of fractures present on the skull has indicated the possibility that La Brea Woman was killed by a number of severe blows to the head with a blunt instrument. Los Angeles's "first lady" would thus also have been its first recorded homicide! A broken mano grind stone, of the sort commonly used by aboriginal women to reduce plant seeds to a powder, was found about 6 feet from the skeleton. Conceivably this could have been the murder weapon. However, if the body of the murder victim was thrown into an asphalt pool in an attempt to dispose of the remains, why is it that so many parts of the skeleton are missing?

There is also another possibility. Ceremonial reburial of human remains was a common and widespread practice among southern Californian Indians. Individuals who died during the yearly round of seasonal movements were placed in temporary graves and parts of their skeletons were later retrieved for reburial elsewhere. The incomplete nature of the skeleton would be consistent with reburial, as would its recorded associations with "grave goods" comprising the skull of a domestic dog, several fragments of ornaments made from sea shells, and the mano grind stone, which may have been ceremonially defaced. If the reburial hypothesis is correct, why this particular spot was chosen for a grave site remains a mystery.

La Brea Woman is the only human fossil so far recovered from the Rancho La Brea deposits. Moreover, this skeleton is younger than most of the more than one million other bones from the tar pits. As man may have reached the New World 25,000 years ago, and as our local area evidently supported a vast quantity of other types of mammals between 9,000 and 40,000 years ago, the apparent rarity of human fossils is rather puzzling.

The temporary loan of the La Brea Woman skull to the American Museum of Natural History will not disrupt any of the current exhibits at the Natural History or Page Museums. Normally this specimen is kept with the rest of Rancho La Brea fossil collection so that it may be readily available for study. Casts of this specimen will remain on display at both locations.

The return of La Brea Woman to Los Angeles in September will coincide with the beginning of the scheduled construction of the RTD Metro Rail system. One of the Metro Rail stations will be located near the western edge of Hancock Park; its construction will almost certainly uncover new Rancho La Brea deposits. It is entirely possible that within the next eighteen months other new human fossils will be found in these deposits and may shed further light on the earliest human inhabitants of the Los Angeles basin.

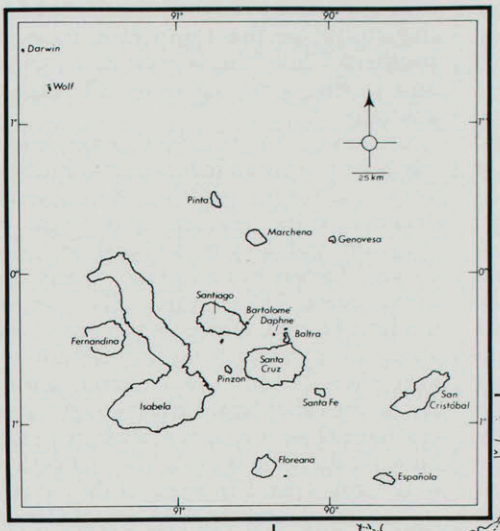
JOHN M. HARRIS
Chief of Earth Sciences

THE ORIGIN AND EVOLUTION OF THE LIZARDS OF THE GALAPAGOS ISLANDS

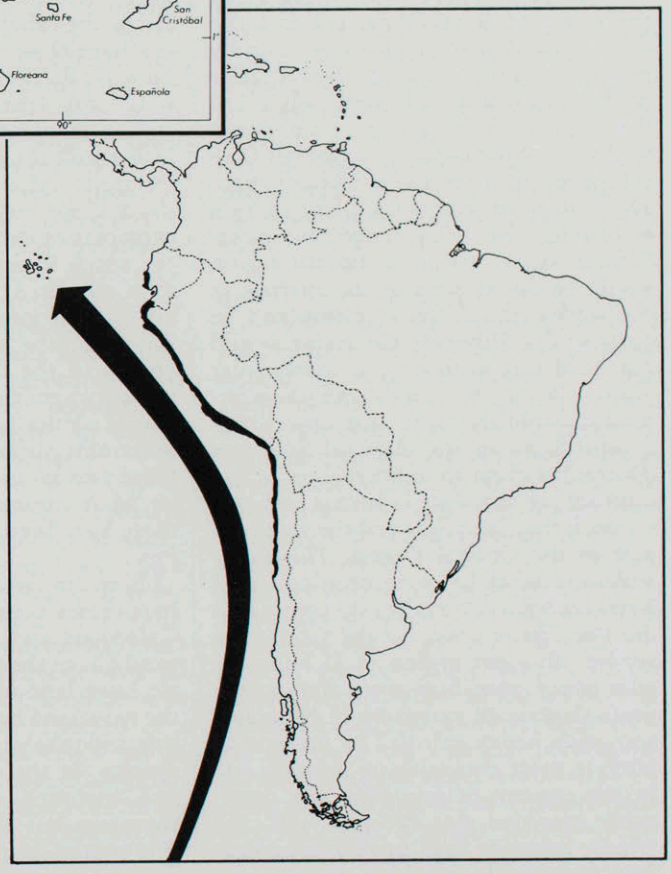
by JOHN W. WRIGHT

The serious study of the natural history of the Galapagos Islands began in 1835, with the historic visit of *HMS Beagle* and Charles Darwin. On reaching the islands, Darwin excitedly entered into his field journal, "The natural history of this archipelago is very remarkable: it seems to be a little world within itself; the greater number of its inhabitants, both vegetable and animal, being found nowhere else." From this onset of biological exploration, studies in the Galapagos have continued to play a prominent role in the development of our understanding of the process of evolution. The Galapagos biota strongly influenced Darwin's ideas, which were later articulated in his theory of evolution. Because of this, much of the world has been fascinated and intrigued by these remote islands. Now, nearly one hundred and fifty years after Darwin's visit, they are an Ecuadorian National Park and an International Scientific Reserve that are visited annually by 30,000 tourists from around the world and dozens of scientists who conduct studies under the auspices of the Charles Darwin Research Station supported by the international Charles Darwin Foundation. Despite this long-term and continuing interest in the islands and their biota, there remain many unstudied or understudied groups of organisms and many intriguing biological questions. The origin and evolution of the poorly known lizard fauna remains one of the most interesting problems.

The Galapagos Archipelago has a fascinating and relatively diverse lizard fauna (see page 26). All species except one are unique or endemic to the islands. Two species, the marine and land iguanas, have no surviving close relatives elsewhere in the world. They are perhaps each other's nearest relative, but distantly so, and are placed in different genera. The nonendemic species is a day gecko that was probably introduced by man to the wetter regions of San Cristobal Island. The remaining lizards are leaf-toed geckos *(Phyllodactylus)* and lava lizards *(Tropidurus)*. There is some debate as to how many species of each of these two groups are on the islands, but usually six species of *Phyllodactylus* and seven of *Tropidurus* are recognized. Virtually every above-water piece of rock in the archipelago has a population of one or both of these genera.



Inset: A map of the Galapagos Archipelago with the Ecuadorian names for the islands.



Below: A map of South America showing the Coastal Desert and the Galapagos Archipelago. Arrow indicates the direction of flow of the Humboldt or Peru Current.

My initial interest in the Galapagos was not due to some romantic desire to conduct research in the Galapagos or even to study its fascinating lizard fauna *per se* but was more to extend my long-term analysis of the evolution and biogeography of the reptiles and amphibians of the deserts of western South America. As you will see, the Galapagos are closely related both climatically and faunistically to this desert region.

The western deserts of South America are the extremely dry, yet cool coastal areas, collectively called the Coastal Desert, west of the Andes Mountains. This Coastal Desert stretches from southeastern Ecuador through Peru to northern Chile and has a total length

of about 1,850 miles but rarely exceeds 65 miles in width. It consists of several subdivisions, the most famous of which is called the Atacama. There are areas in this great desert that have not received a drop of rain in recorded history. Lima, the major city in the desert and capital of Peru, averages one inch of rain every 25 years. In general, the desert is harsh with vast expanses virtually devoid of living organisms.

Climatically, both the Galapagos and the Coastal Desert are dry for the same reasons. Chief among them is the presence in the eastern Pacific Ocean of the Humboldt or Peru Current. This is a broad cold-water current that is pushed northward by winds from Antarctica and the polar Pacific along the west coast of South America to about the Peru-Ecuador border, where it turns westward and flows to and beyond the Galapagos. Where winds and currents pass near land there are extensive cold-water upwellings. The result is a broad band of cold water hundreds of miles wide that constitutes an effective rain shield along the coast of South America and the Galapagos. Moisture-laden air rapidly reaches its dew point at the western edge of the cold water, and essentially all of the moisture falls as rain in the ocean well west of the coast. The Coastal Desert is even drier because the Andes virtually eliminate the possibility of rain reaching the area from the east. Climatologists maintain that the region would be desert even in the absence of the Andes; the desert just wouldn't be quite so dry. However, the region would not be desert without the south polar winds. When the winds and their attendant cold currents and upwellings diminish as in the Austral Summer (December through February), it is not unusual for moisture-laden air and rain to reach the Galapagos and the northern part of the Coastal Desert. This rainy season is what has long been called El Niño, in reference to the rain coming, as did the Christ child, in the Christmas season. To some degree an El Niño occurs every year, but every five to ten years there is an extensive El Niño season with heavy rains. The present El Niño is more extensive in duration and in the amount of rain than any previously recorded. For the past year, the winds, currents, and upwelling associated with the Humboldt have virtually stopped. Rain and warm tropical temperatures have been an almost everyday occurrence in the Galapagos and northern Coastal Desert. This year in the Galapagos, instead of measuring the rain in inches or millimeters, it was measured in yards and meters.

Biogeographically, the Coastal Desert is well isolated from the rest of South America by the Andes. The elevation of the continental divide formed by the Andean Cordillera rarely drops below 19,000 feet, and the lowest pass through the mountains is over 8,000 feet. The desert is also well separated from other dry regions to the north and south by two of the wettest regions in the world. To the north is the Choco of Colombia, one of the world's wettest tropical areas with over 500 inches of rain annually; and to the south lie the temperate areas of southern Chile, the wettest nontropical area in the world with over 275 inches annually.

By some estimates, the Coastal Desert has been in existence for over 40 million years, making it one of the oldest deserts. Because of its great age and extent of isolation, and despite the harshness, the Coastal Desert has a unique, highly endemic biota. This is especially true for the lizard fauna, where 98 percent of the species are endemic. Interestingly, however, there is only one endemic genus. All of the other lizard groups (eight genera) have close relatives elsewhere in the New World. This is probably a reflection of the long-term harshness of the desert.

The lizard fauna of the Coastal Desert is dominated by members of two genera, *Phyllodactylus* (11 species) and *Tropidurus* (7 species). Over most of the desert, members of these two genera constitute the entire lizard fauna, and in the desert as a whole, 62 percent of the species are in these two genera. As noted above, these are the two most diverse lizard groups in the Galapagos. This similarity between the mainland and island faunas naturally led me to ask questions pertaining not only to how the lizards in these two areas are related but to when, by what means, and how many times there have been interchanges.

THE ORIGIN AND EVOLUTION OF THE LIZARDS OF THE GALAPAGOS ISLANDS

There are two general biogeographical hypotheses concerning the origin of the Galapagos and its biota. One scenario would have the proto-Galapagos as a single large land mass attached directly to the mainland by at least a narrow peninsula and inhabited originally by very few species. In the cases of *Phyllodactylus* and *Tropidurus*, it was hypothesized that there was just one species in each genus. The proto-Galapagos began to break up, first by disconnecting from the mainland; then by gradual and partial submergence the present configuration was reached with the passage of considerable time. With each "break-away" of a new island, evolution or speciation in isolation occurred, leading to the considerable diversity in each group. Darwin subscribed to this hypothesis in a general way; and, although it is not popular today, it continues to attract vocal advocates.

John Van Denburgh and J.R. Slevin in 1912 were the first and last individuals to comprehensively study the *Phyllodactylus* and *Tropidurus* of the Galapagos and were strong supporters of this hypothesis. They coined the term "Galapagos Land" for the original large land mass or proto-Galapagos and presented the following discussion as the basis for their advocacy.

"The fact that these lizards occur on nearly every island of the archipelago can be explained only in one of two ways. These *Tropiduri* must have reached these islands either by land or by water. Either they have been carried to each island, islet, and rock by some such means of dispersal as floating driftwood driven by the winds and currents, or else they were already on each island at the time when it became separated from a larger land-mass. The former view has been held by those who believe that these islands never have been connected, but have been independently thrust above the surface of the ocean. The latter explanation finds favor with those who believe that these islands all formerly were connected, and formed part of a single large island which, sometime, must have been connected with continental America.

"We can see but little to commend the former view, for the means of dispersal from continent to island or from island to island over the intervening water must, in the nature of things, be but accidental or occasional, and must seem quite inadequate to account for the wide distribution of these lizards in the archipelago. Again, Wenman [Wolf] and Culpepper [Darwin] lie directly in the path of the currents from the other islands, yet both are without *Tropiduri*. Furthermore, were such means of dispersal sufficient to bring about the wide distribution of these reptiles, we must believe that the interchange of lizards between the islands would result either in preventing differentiation on the various islands, or in the transportation of differentiated races from island to island. Thus we should expect to find either one kind of lizard on all the islands, or a tendency toward the distribution of all kinds of lizards to each island. But many of the islands have each its peculiar kind of *Tropidurus*, and no island has more than one kind. Even in the case of Duncan [Pinzon], almost surrounded as it is by other close-lying islands, the evidence all points to complete isolation during a long period of time.

"We therefore, adopt the other theory: that there formerly was a single large island inhabited by one species of *Tropidurus*; that through partial and gradual submersion this island became divided into the many islands of the present archipelago; that each island after its separation was occupied by those animals which inhabited it before; and that the present fauna of each island is directly

descended from its original inhabitants.

"It is probable that the separation of the various islands occurred at different times rather than simultaneously.

"If it be admitted that the degree of differentiation in a single group, under conditions such as obtain in these islands, may be regarded as an index to the period of isolation, we may proceed to sketch the history of the archipelago as indicated by the lizards of this genus."

In the scenario for the alternative hypothesis, the islands are of volcanic origin and have been thrust independently above the surface of the sea. They are therefore truly oceanic islands that have never been connected to the mainland and rarely if ever with each other. The lizards on the islands owe their presence to over-water transport either floating in water or riding some floating object. Over-water transport would be the mode of transport of both immigrants from extraneous sources (mostly South America) and for interisland movement.

This oceanic biogeographic hypothesis has received considerable support from modern geological studies. Allan Cox of Stanford University has recently summarized the available geological data pertaining to the origin and development of the archipelago. These data are from four kinds of studies: plate tectonics, paleomagnetic dating, radiometric dating (potassium to argon), and geomorphology. The tectonic data indicate that the archipelago rests on the Nazca Plate, which is sliding southeastward and subducting under the South American Plate at the Peru-Chile trench. Thus, the archipelago is now closer to South America than it has ever been but not as close as it will be tomorrow. As noted by Dr. Cox, the Galapagos are destined to slide completely under South America in 20 million years.

The sea floor around and under the Galapagos is less than 10 million years old and was probably formed about 9 million years ago. Direct dating of the islands is difficult, as the older rocks on volcanic islands tend to be covered by younger rocks and the lavas may have been submarine when formed. Even with these complexities, there appears to be a general age trend, with the southeasternmost islands (San Cristobal and Española) being the oldest and the westernmost (Fernandina and Isabela) the youngest. The dates for the islands range from about 700,000 to nearly 4 million years. The age trend is sufficiently linear and regular to substantiate a "hot-spot" model of origin for the archipelago. Briefly, there is a stationary active volcanic plume zone or hot spot, over which the Nazca Plate slides. As the plate passes over the plume zone, lava is deposited that in some cases is sufficiently high to emerge from the sea and produce islands. Dr. Cox has used the rate of plate movement over the plume zone, as determined by direct dating of the sea floor, to calculate estimated ages for the islands. The calculated ages, which are based on a rate of movement of 68 mm (2.68 inches) per year, correspond well with those determined by paleomagnetic and radiometric analyses and indicate a maximum age of the first island (probably San Cristobal) of 3.7 million years.

As I have already mentioned, the large amount of similarity in the lizard faunas of the Galapagos and Coastal Desert prompted me to ask various questions pertaining to their relationships. Since all species of each genus presumably descended from their respective common ancestors, one might be able to ascertain with the proper data not only how these lizards might be related but also when, by what means, and how many times interchanges between the mainland and the island might have occurred. In doing so, it also might be possible to evaluate the two major biogeographic hypotheses for the Galapagos. At the time of my initial interest in this problem, the only information available on these lizards was very meager data on their external morphology (color, color pattern, and scale numbers and placements), behavior, and ecology, none of which would have been useful in addressing the questions that I had posed. Even gathering more of these types of information did not appear to be a very promising way to proceed. However, there was a relatively new method of investigation, called allozyme analysis, that allowed inferences about genetic relationships to be made. Since what I would actually be attempting to do would be to reconstruct the genealogies of these lizard populations, it appeared highly desirable to use an approach with a genetic basis.

Allozymes are alleles or alternative forms of enzymes and other proteins. Each protein is a product of a single gene and is a large chain-like molecule made of smaller units called amino acids. Amino acids are the fundamental units coded by DNA, the genetic code material of higher organisms. Thus, a mutation in DNA generally will be reflected in a change in the amino acid coded and in the overall protein molecule. This different protein would be considered an allelic form of the protein containing the unmutated amino acid sequence.

By way of a simplified example, an enzyme molecule might be made up of a string of 200 amino acids, 30 of which are critical for determining shape and function of the molecule. The remaining 170 amino acids would be "spacers." For the most part it is of no significance what amino acids are present at these sites so long as the proper number or space is maintained between the 30 shape or function amino acids. Generally, a change in one or more amino acids in the spacer regions does little more than change the electrical charge of the molecule. A change in amino acid in one of the "functional" regions would result in a change in function and in a fundamentally different molecule. As most of the proteins used in allozyme analyses are basic metabolic enzymes that are critical to normal cell, tissue, and organ physiology, functional changes in them are rarely encountered. Such changes undoubtedly occur, but the organisms with them would be quickly eliminated as non-viable or, as is more commonly phrased, the mutations would be subjected to natural selection. The mutations that result in nonfunctional changes are called "neutral mutations" as they are free from natural selection, and the process of their origin and maintenance is termed "non-Darwinian evolution." Whether or not allozymes are subjected to natural selection is still debated in scientific circles, but it appears that selection is rare at best and selection pressure is miniscule at most. Thus, allozymes can be defined as allelic forms of a protein (that is, coded by the same gene) that have different molecular structure with no functional differences.

Starch-gel electrophoresis is one of the simplest, most direct methods of assessing allozymic variation. The small differences in electric charges of the proteins and enzymes that arise from changes in the amino acid composition are used to identify the alleles.

Since there is one locus or site for a given gene on each set of chromosomes, it is possible to have only two alleles of a gene in the same individual in a standard diploid organism. Allozymes differ from alleles of some other genes in that both alleles are expressed rather than one being dominant and the other recessive as in classical Mendelian genetics. Different alleles in the same individual form a characteristic heterozygous or multibanded pattern. While it is only possible to have two alleles per gene locus in the same individual, it is possible to have numerous alleles per gene in a population or species. For example, in the *Tropidurus* analyzed, at the most variable gene locus (an esterase) there were six alleles in the eighteen populations sampled, three of which occurred in the same sample. Ten of the eighteen samples had only a single allele but not always the same one. Each individual tissue sample is scored for each gene locus, and a gene frequency (percentage of alleles at a gene locus) is determined for alleles per gene for all loci in the populations sampled. All gene frequencies for each population are then compared to those of all other populations to develop a matrix of indices of genetic similarity.

The most commonly used index or measure of genetic similarity (Roger's S) ranges from 0 to 1 or from 0 to 100 per-

cent similarity. The amount of similarity among populations is a measure of genetic relatedness, and the overall relatedness of a group of populations is most commonly expressed in some form of tree diagram as I have done here (see opposite page).

There is also a very general relationship between a genetic similarity value and the relative status of populations. For example, if the genetic similarity value between two lizard populations is between 0.95 and 1.00, the two populations are likely to represent the same genetic population of a species. Lower values indicate less genetic relatedness and more distant relationships, as follows:

Roger's Genetic Similarity	Relationship
0.85–0.95	Different populations and/or subspecies of the same species
0.85 or less	Different species
0.60 or more	Same species group
0.60 or less	Different species groups
0.40 or less	Different genera

It should be emphasized there is only a general relationship between the two, and that, in the absence of other biological data, it is not wise to use genetic similarity as a yardstick for the biological relationship of two populations. The most commonly encountered failures of the relationship are cases where related but distinct biological species have high levels of genetic similarity. An excellent example is from a study in which two similar coexisting but noninterbreeding species of North American snakes were found to have 0.97 genetic similarity. However, in order to obtain genetic similarity values less than 0.90 between two populations, there must be absolutely different alleles at some gene loci. The presence of different alleles is an indication that the two populations are not exchanging genes (hybridizing), and the more gene loci with differences, the greater the likelihood that they could not successfully hybridize. Generally, if two populations are incapable of forming viable hybrids, they are considered to be at least distinct species.

Another genetic index, Nei's Genetic Distance, is a more complex measure that is predicated on a number of assumptions concerning the constancy of mutation rates and the amount of evolution in a molecule necessary to obtain an electrophoretically detectable change. It ranges from 0 (no difference) to well beyond 1.0, 2.0, or even 3.0. It is a more difficult measure to conceptualize, but it has a special utility not shared with Roger's Similarity. By the use of multiple correlations, it has been demonstrated that there is a relationship between Nei's Distance and the amount of time since the populations diverged. This relationship depends on the presence of non-Darwinian evolution in allozymes where the alleles are the results of neutral mutations that occur randomly or stochastically and are at no time subject to direct natural selection.

The relationship between time and genetic distance was first obtained for mammals, where, from the fossil record, it is possible to determine relatively accurately when two lineages diverged. When the divergence times were compared with Nei's Distance values for descendants of some fossil groups, it was established that approximately 18-20 million years are needed to accumulate 1.0 of Nei's Distance. This mammalian calibration of the molecular clock has been widely applied to studies of other groups, including lizards, salamanders, crocodilians, snakes, and birds, where the fossil records are much more incomplete. While a relationship appears to exist between the ages of the Galapagos Islands and Nei's Distances for their respective lizard populations, the lizard clock appears to tick much faster, as discussed below.

From an evolutionary or biogeographic standpoint, it is assumed that an allele only evolves once (unless there is some evidence to the contrary) and that two populations have the same allele owing to descent from a common ancestor. The more alleles two populations share, the more closely related they would be, and the smaller the relative amount of time since they diverged from a common ancestor.

THE ORIGIN AND EVOLUTION OF THE LIZARDS OF THE GALAPAGOS ISLANDS

My first visit to the Galapagos was in 1972 as Chief Scientist on a multidisciplinary biological expedition aboard the Research Vessel *Searcher* of the Janss Foundation. We departed from Puntarenas, Costa Rica, and spent more than a month visiting all major islands and many smaller islands to conduct our biological investigations. My efforts were directed toward securing frozen tissue samples of *Phyllodactylus* and *Tropidurus* from as many islands as possible for analyses of allozymes. This trip was highly successful, and we began our return trip to Costa Rica. Six hours from port, the ship caught fire, burned to the water line, and sank. No one was injured, but all was lost save the meager clothing we were wearing (not even one pair of shoes among 12 people). Fortunately, we were rescued by a passing freighter and deposited two days later in Acapulco, Mexico.

In 1974 most of the original scientific crew of the 1972 expedition, joined by a few others, made brave to revisit the Galapagos. For this expedition, we flew to the islands and made use of the research vessel of the Charles Darwin Research Station, the *Beagle III*, as our interisland transport and laboratory. Again, we visited all major islands and many of their satellites, and I was able to secure sufficient frozen tissue samples to conduct the allozyme analyses. I sampled seventeen populations of *Phyllodactylus* and eighteen of *Tropidurus* from fourteen and fifteen islands, respectively. All major islands and many of the satellite islands of known occurrences of the two groups were represented by tissue samples.

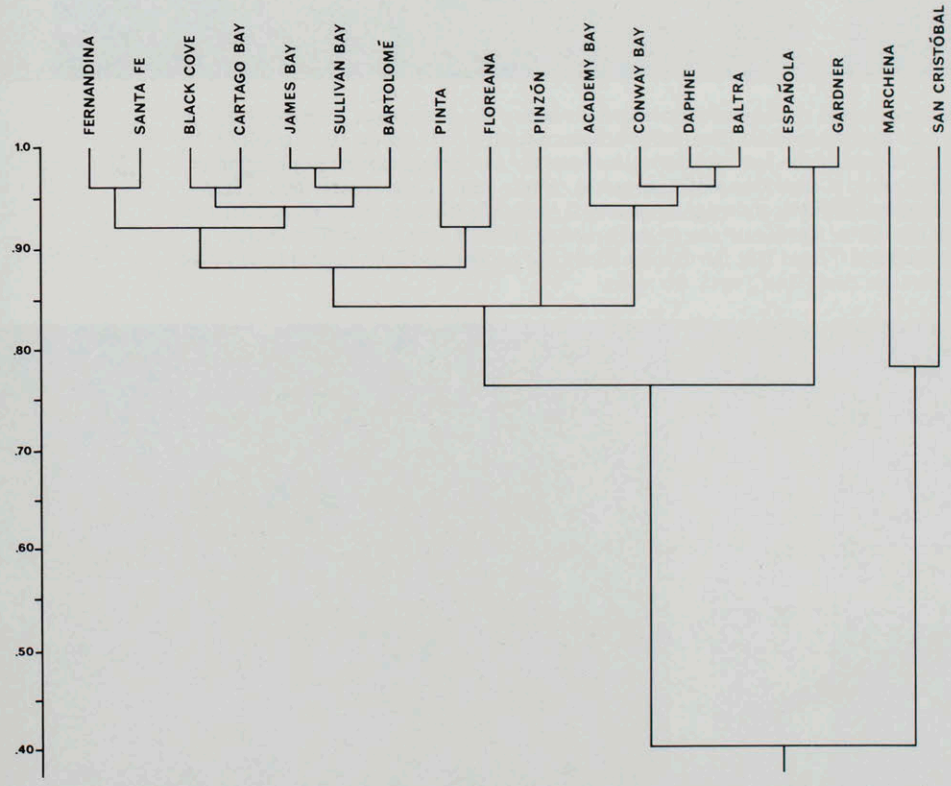
For the purposes of the analyses, I disregarded all estimates of the number of biological units (species and subspecies) and treated the samples that were collected as though they were derived from local populations of a single wide-ranging species of each genus. The samples are thus referred to by collection locality and not by scientific name. The names used for the localities (see the tree diagrams) are the Ecuadorian names for the islands except for Tagus Cove, Black Cove, and Cartago Bay on Isla Isabela; Academy and Conway Bays on Isla Santa Cruz; and James and Sullivan Bays on Isla Santiago. The two samples of *Phyllodactylus* from Isla San Cristobal (L and D) represent the co-occurring populations on this island.

From the frozen tissue, I was able to analyze 70 alleles of 20 gene loci in *Phyllodactylus* and 72 alleles of 23 loci in *Tropidurus*. The results of these analyses are presented in the tree diagrams. The Roger's Genetic Similarity values were as low as 0.38 in *Phyllodactylus* and 0.29 in *Tropidurus*. The most divergent populations in both groups occur on Isla San Cristobal. Population samples from the same islands and from adjacent satellite islands have high levels of similarity, except for the two co-occurring (sympatric) populations of *Phyllodactylus* on Isla San Cristobal (0.44). The samples of each genus from the more central and western islands have similarity values averaging higher than 0.81.

The tree diagrams produced by a method that averages the similarities identified two divergent branches or distantly related groups in the *Tropidurus* samples with an average similarity of 0.40 between them. One branch contains only the samples from Islas San Cristobal and Marchena. The tree from the *Phyllodactylus* data revealed four strongly divergent branches: San Cristobal (D), Wolf, San Cristobal (L), and the remaining samples including Española.

The results of the allozyme analyses were compared with the fully detailed Galapagos Land Biogeographic Hypothesis of Van Denburgh that was derived from a morphological analysis of the Galapagos *Phyllodactylus*, *Tropidurus*, and snakes. There are a number of

A tree diagram of the genetic relationships of the populations of leaf-toed geckos (Phyllodactylus) *of the Galapagos Archipelago based on allozyme data. The scale is in Roger's Genetic Similarity values.*



A tree diagram of the genetic relationships of the populations of lava lizards (Tropidurus) *in the Galapagos Archipelago based on allozyme data. The scale is in Roger's Genetic Similarity values.*

marked discrepancies. Generally some of the same more divergent branches (islands or populations) are identified both in the *Phyllodactylus* allozyme data and by Van Denburgh; however, the Galapagos Land Hypothesis does not agree with the *Tropidurus* allozyme data. If both *Phyllodactylus* and *Tropidurus* had shared the same history as dictated by the Galapagos Land Hypothesis, there should have been a high degree of similarity in the branching sequences in the trees derived from the allozyme data from both groups. On the contrary, both groups appear to have had independent histories of evolutionary diversification in the islands. Thus, both the allozyme and geological data indicate that the Galapagos Land Hypothesis is not sufficient to explain the patterns of evolutionary divergence in the lizard populations.

The allozyme and geological data are in high accord with each other. The older eastern islands have the genetically most divergent populations of both lizard groups. The younger western and more centrally located islands have populations that are much more similar genetically. Thus, the allozyme data support the hot spot model of origin for the archipelago.

When the allozyme data are expressed in terms of Nei's Distance, it is possible to calibrate a molecular clock using the ages of the islands and the Nei's Distances for their respective lizard population. For example, it is clear from the geological data that Islas Española and Santa Cruz are each about three million years old. Assuming that lizards arrived on these islands shortly after they were formed, the Nei's Distance values between the populations of *Phyllodactylus* and *Tropidurus* on Islas Española and Santa Cruz can be set at three million years. The clocks thus calibrated yield 8.9 and 10.2 million years for a Nei Distance of 1.0 for *Phyllodactylus* and *Tropidurus*, respectively. It is now possible to assign ages to the various forks in the allozyme trees.

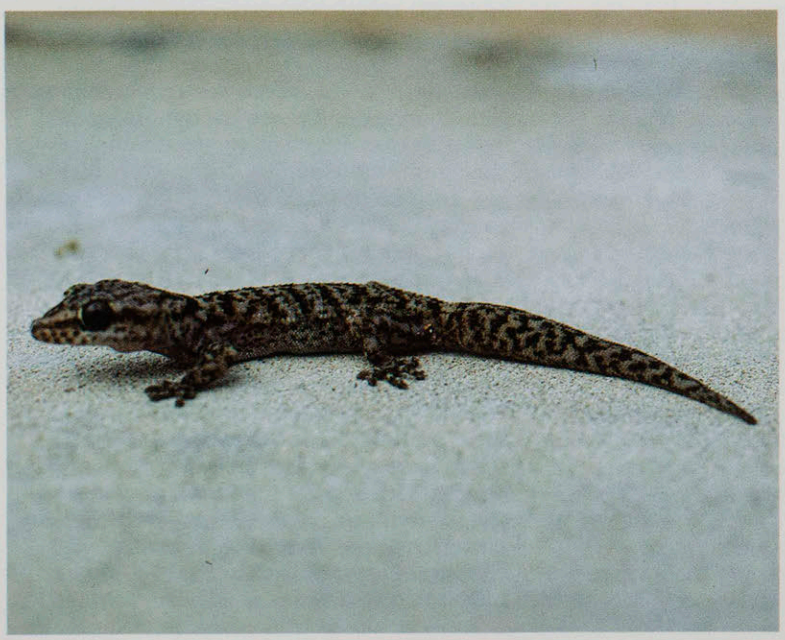
In the *Phyllodactylus* tree, it is clear that some of the diversification in both lizard groups is older than the archipelago and that some of the evolutionary divergence must have occurred before the animals reached the Galapagos. For example, beginning from the base or root of the tree, the ages of forks 1 (6.4 my) and 2 (4.7 my) both exceed the age of the archipelago. But the age of fork 3 (3.7 my) leading to San Cristobal (L) matches exactly the age of the island predicted by the geological data. If all of this is true, then at least three separate foundings would be needed to establish *Phyllodactylus* initially (the ancestors for Wolf and San Cristobal D and L). All remaining *Phylodactylus* on the younger islands could have been derived sequentially from the ancestor of San Cristobal L, on the oldest island.

THE ORIGIN AND EVOLUTION OF THE LIZARDS OF THE GALAPAGOS ISLANDS

The divergence times calculated for the *Tropidurus* tree indicated that the amount of time since fork 1 (9.5 my) leading to the two major Galapagos lineages far exceeds the age of the archipelago. Again, it is clear that much of the evolutionary divergence between these two groups of lizards occurred on the mainland before *Tropidurus* reached the islands. Indeed, a preliminary comparison of allozymes between island and mainland *Tropidurus* indicates that the San Cristobal and Marchena samples are genetically more closely related to some mainland species than they are to the other island populations. Thus, there were two foundings of *Tropidurus* in the Galapagos. One was to Isla San Cristobal, which in turn provided founders for Marchena, and the other was to Isla Española, which may have served as the source of founders for Isla Santa Cruz and the other central and western islands.

With respect to the questions I posed regarding the origin and evolution of the lizards of the Galapagos, it is reasonably safe to conclude that the source of the founders of the Galapagos Islands populations was the Coastal Desert of western South America where related species of *Phyllodactylus* and *Tropidurus* now occur. There is little support from allozyme analyses for Van Denburgh's Galapagos Land Hypothesis. Rather, the long-term existence of the Humboldt or Peru Current played an essential role in the independent, multiple transport of founder lizards to the islands. Considering the age of the archipelago, three separate foundings for *Phyllodactylus* and two for *Tropidurus* are necessary to explain the colonization of the Galapagos. Moreover, the relative genetic similarity of the lizard populations is generally consistent with the predic-

Representatives of the endemic lizard species of the Galapagos Archipelago. Upper left: marine iguanas (Amblyrhynchus cristatus) *basking on Isla Española. Upper right: one of the few remaining survivors of the nearly extinct population of land iguanas* (Conolophus subscristatus) *on Isla Santa Cruz. Lower left: a leaf-toed gecko* (Phyllodactylus galapagoensis) *from Isla Isabela; these geckos are the only nocturnal lizards on the islands. Lower right: a lava lizard* (Tropidurus albemarlensis) *from Isla Bartolome. Only the geckos and lava lizards have close relatives in mainland South America.*

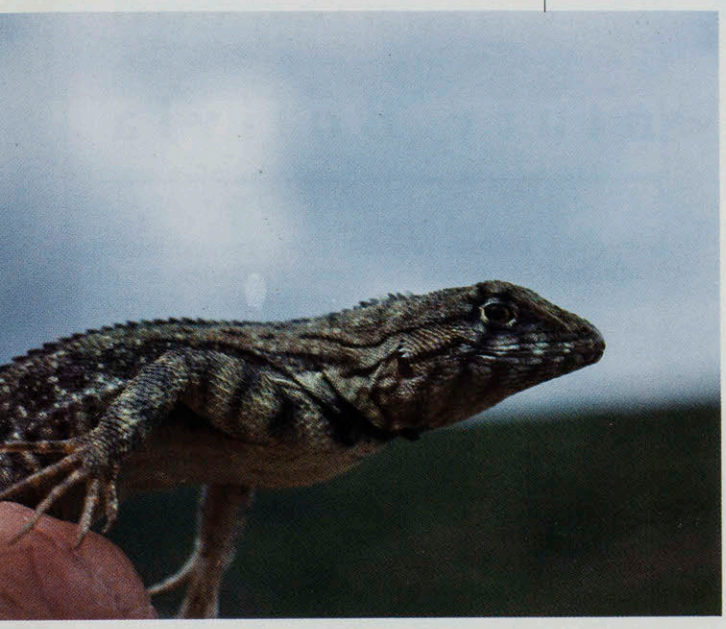


tions from a geological hot spot model.

Although the allozyme analyses discussed here have provided interesting new perspectives on the origin and evolution of the lizards of the Galapagos, the study is far from complete. The next of several phases of my research on the problem will be focused on testing the hypotheses I have generated here by analyzing the allozymes of the mainland populations of *Phyllodactylus* and *Tropidurus* and comparing them to the island populations. Most of the required samples have already been gathered, and pending the availability of time and resources, I will initiate the laboratory analyses in the near future.

Dr. Wright is Curator and Head of the Section of Herpetology at the Natural History Museum. His primary research interest lies in understanding the evolution of reptiles and amphibians. In addition to his studies of the lizards of the Galapagos, he is well known for his research involving all-female species of lizards. He contributed a chapter detailing some of his work with the Galapagos lizards to the recently published book, Patterns of Evolution in Galapagos Organisms, *edited by R.I. Bowman and others (Pacific Division, American Association for the Advancement of Science, 1983).*

Photographs by the author; maps and diagrams by Mary Butler and Joe Nakanishi, Museum Illustrators.



Representative individuals of lava lizards from the Galapagos Archipelago and the deserts of western South America. All species have marked sexual dimorphism in color, color pattern, and size. Upper left and right, male and female, respectively, of Tropidurus stolzmanni, *one of eight species in Peru. Lower left and right, male and female of* Tropidurus albemarlensis *from Isla Santa Fe, one of about seven species of lava lizards endemic to the Galapagos Islands.*

AYMARA WEAVINGS

Ceremonial Textiles of Colonial and 19th Century Bolivia

Bolivian textiles are the legacy of a 3,000 year old weaving tradition existing in the area around the Lake Titicaca Basin Plateau, the ancient home of the Aymara Indians. Until the end of the 19th century, the Aymaras preserved intact pre-Columbian weaving techniques, designs, colors, and forms in Bolivia. Historically, cloth had social and cultural prominence in all facets of Indian life. These ceremonial pieces, which were handed down from generation to generation as heirlooms, show the Aymara weavers' versatile sense of color, imagination, and technical skill in weaving, spinning, and natural dyeing.

An exhibition of Bolivian textiles, Aymara Weavings: Ceremonial Textiles of Colonial and 19th Century Bolivia, will open at the Natural History Museum on May 15, 1984, and remain on view through June 24, 1984. The exhibition, located in the Director's Gallery on the second floor of the museum, will feature sixty-five weavings that are characteristic of Aymara ceremonial textiles including ponchos, ccahuas (tunics), urkus (skirts), ahuayos (mantles), and ch'uspas (coca bags). Accompanying the weavings are large color photographs of Indians in full ceremonial dress, providing an ethnographic reference to the textiles. The full-color catalog of the exhibition discusses the origins of the textile forms and their development, continuity, and change as a consequence of Spanish colonization.

The exhibition was organized by the Smithsonian Institution Traveling Exhibition Service (SITES), and objects were selected and researched by Laurie Adelson and Arthur Tracht. It will travel to thirteen cities through 1985.

Clockwise, from left above: Ccahua (tunic), early Colonial period, 32 by 33 inches. Ponchito, nineteenth century, 37 by 45 inches. Ch'uspa (coco bag), nineteenth century, 11 by 12 inches. Ch'uspa, nineteenth century, 10 by 19 inches. Huaka (belt), nineteenth century, 55 by 5 inches. Photographs courtesy of Smithsonian Institution Photographic Services.

(Continued from page 2)
museum collections and new demands on museums for preservation and storage of materials.

Today there are hundreds of millions of specimens housed in the world's natural history museums. This world collection documents our natural heritage, providing information on both common plants and animals and on those that have become extinct as man uses more and more of the earth's surface for societal needs.

In the Natural History Museum of Los Angeles County we care for and study approximately 15 million specimens. Our collection is a relatively young one in terms of the world's major natural history institutions; yet it is still one of the country's largest and has international stature. No collection of this size will have all or even a major portion of its specimens either on display or under study at any one time. However, over the decades, and in some cases over the centuries, most of these specimens will be examined and used either in research or in public programs. It is this aspect of long-term preservation that is the most fundamental tenet of museum responsibility.

This issue of TERRA contains articles on portions of the museum's collections acquired over fifty years ago that form the basis for two fascinating investigations today. One deals with one of the first of the early man sites discovered in North America, the other with an extremely important fossil whale excavated years ago. Both illustrate the lasting importance of the museum's role as custodian and preserver of our heritage.

CURATORS & COLLECTIONS

Letter to the Editor

On the second page of the article entitled "Mountain Greenery and Southern California Scenery" (TERRA, Nov/Dec 1983), author David Minor...refers to "those increasingly rare days after a rain when one discovers mountains on a definable horizon behind downtown Los Angeles." As a southern California enthusiast I did a little research...those in the know [say] that clear days are increasingly *less* rare. In other words, environmental safeguards are having a beneficial impact on our atmosphere... When I first moved to southern California in 1953 backyard incinerators were the vogue. I lived in Pasadena and often could not see two blocks up the street...I recognize that that kind of smog is less deleterious in many respects than the type produced by a combination of sunlight and pollutants. Even so, I am assured the worst kinds of smog are not only being held in check but reduced, and my personal experience supports this view.

Incidentally, I am writing this on November 22 and I think yesterday was the record holder for good visibility during the past several years.

Perhaps Mr. Minor will be interested in my comments. I do not intend to be critical—just enthusiastic about our part of the world.

C. P. "Perry" Mirton
Rosemead, California

David Minor replies: My mood was clouded and befogged by the similar weather we were having when I wrote the article. Here in downtown Los Angeles where I live the coastal fog is seemingly becoming more predominant and rain is surely increasing. This is not bad at all. I am sure it is just a seasonal thing—a byproduct of El Niño?—and even if smog were a thing of the past, the mountains would still be shrouded in clouds of some sort. Besides, the effect of light and air on the vistas north of downtown after a rain is worth waiting to see. It is always a breathtaking sight—not at all related to the breathtaking abilities of pollutants.

Museum's Ant Collection Now America's Largest

Because of recent acquisitions, the Natural History Museum now has the largest and one of the most important collections of ants in the Western Hemisphere. The museum thus assumes an immense significance in research on this ubiquitous family of insects, which are involved in many ecological relationships of academic and practical relevance. There are well over 12,000 different species in the world, a substantial percentage of which are now represented in our museum. Specialists from countries all around the globe utilize our ant collection for research into such diverse topics as taxonomy and classification, adaptation to desert plants such as the creosote bush, dispersal of serious pests such as fire ants, stings and other protective chemistry, and social structure. Such scientific studies will be further facilitated and stimulated by the availability in one place of so many different species and genera.

Although our holdings were already notable, our recent pre-eminence is due to the activities of Roy R. Snelling, Curatorial Assistant in Entomology, who recently returned from the East Coast with two important acquisitions (see TERRA, Jan/Feb 84).

California Association of Museums Moves to the Natural History Museum

The California Association of Museums, the first nonprofit service organization to represent all the museums in the state, has relocated its office to the Natural History Museum. Catherine Naughton, who has recently joined the association as the executive assistant, staffs the new offices located in the Education Division at the museum. Leon G. Arnold, Assistant Director of the museum, is on the association's board of directors.

C.A.M.'s goal is to assist California museums by promoting the sharing of resources and disseminating information regarding fund raising, public awareness, and museum administration. The association has sponsored practical workshops in many areas important to museum administrators and is actively monitoring the state legislature to inform California museums of issues that will affect their programs.

Alcalde Papers Acquired

Invaluable documents dating from over one hundred and fifty years ago have been acquired by the Natural History Museum. These civil and criminal court records will help to fill enormous gaps in historians' knowledge of the Mexican period and early American period in Los Angeles.

By order of the Superior Court and the County Board of Supervisors, a number of bound volumes of original court records have been placed in the museum's Seaver Center for Western History Research. At this study center for scholars and other historical researchers, the documents will be preserved for the use of historians investigating scores of subjects relating to the area's past.

For example, the records contain the chain of title to Rancho Rodeo de las Aguas, a large tract of land that had been granted to José Cristóbal Palomares, Ricardo Béjar, and María Rita Valdez de Villa for agricultural purposes in 1821. Besides change of ownership numerous times, this rancho is particularly distinguished for its eventual disposition: it is now the city of Beverly Hills.

Hundreds of criminal cases are also included among the court records. Because there were no newspapers published

The People of the State of California — Versus Joseph Caddick & Charles Norris

In the Court of Sessions of Los Angeles County — June Term A.D. 1852.

Joseph Caddick and Charles Norris are accused by the Grand Jury of the county of Los Angeles, by this Indictment, of the crime of "An assault with an intent to commit Murder, done as follows, to wit:

The said Joseph Caddick, in the county of Los Angeles, on the Fourth day of July A.D. One thousand Eight hundred and fifty two, with force and arms, and a deadly weapon, to wit, a Colt's pistol, loaded with powder and six leaden balls, having the tubes capped with percussion caps, which he, then and there, in his right hand had and held, unlawfully, feloniously and of his malice aforethought, in and upon the person of James R. Barton, then and there being, did make an assault: And the said Joseph Caddick, then and there, said pistol, charged as aforesaid, did shoot off and discharge at, towards, and near the person of said James R. Barton, with the intent unlawfully, feloniously and of his malice aforethought him, the said James R. Barton, to kill and murder.

And the said Charles Norris was then and there present aiding, abetting and assisting the said Joseph Caddick in his said assault with the intent thus to kill and murder the said James R. Barton.

And so the said Joseph Caddick and Charles Norris, in manner and form as aforesaid, in and upon the person of the said James R. Barton, did make an assault,

A document from the Alcalde papers in the Seaver Center for Western History Research.

in Los Angeles until 1851, historians must rely on original documents such as these court records for an understanding of the period before this date.

Referred to as the "Alcalde Records," this body of documents dates back to the 1820s, when an *alcalde*, or mayor, headed the town council in Los Angeles. Besides the executive authority the alcalde held as president of the *ayuntamiento*, he also exercised wide judicial and legislative authority.

In the American period, after 1848, alcaldes were still major civil authorities, and the documents amassed by the Los Angeles alcaldes dealt with land ownership disputes, contracts, estates, and a variety of other civil matters.

New Book for Fossil Collectors!

Former Natural History Museum Curator of Vertebrate Paleontology J. Reid Macdonald needs no introduction to long-time TERRA readers. Before moving on to less-smoggy pastures, Dr. Macdonald contributed numerous popular articles on paleontology to this magazine. He also has published many others in "rockhound" magazines about the proper (and improper) ways for hobbyist and amateur fossil collectors to practice their calling. It is not surprising then that he has brought it all together in book form with *The Fossil Collector's Handbook, A Paleontology Field Guide* (1983, Prentice Hall, 193 pp., $8.95).

The book covers the nature of fossils, where they are to be found, and how they are identified, with major parts devoted to detailed instructions on how they should be collected and how a field camp should be run. The light banter with which Dr. Macdonald writes does not mask his authoritativeness. He is a top-ranking scientist, and his information is based on many years of personal experience and on his interest in the field methods of great American paleontologists of the past.

Only similarity of purpose classes this charming handbook and field guide with the many drearily didactic little books that have been aimed at the American nonprofessional paleontologist. It should replace many of the previous efforts and make it unnecessary to publish others for a long time. As an example of its uniqueness, Dr. Macdonald gives readers his home address and invites them to write him questions and send him specimens for identification.

The book, which I recommend for hobbyist, amateur, and student paleontologists of all ages, is available in the Museum Book Shop.

EDWARD C. WILSON
Curator of Invertebrate Paleontology

IN THE ETHNIC ARTS SHOP,
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The weavings of the Aymara tribe of Bolivia are perhaps the most spectacular in the world. Often featuring real and imaginary creatures, these fabrics are intricate in detail, and exhibit a sophisticated and refined sense of color and design.

Aymara weaving had its origins in Pre-Columbian times and arose in response to a need for clothing. Over the years, complicated techniques and designs evolved, and the Aymara developed their own distinct styles, making the weavings a significant element in their lives.

The weavings offered for sale in the museum's Ethnic Arts Shop complement an upcoming exhibit—Aymara Weavings: Ceremonial Textiles of Colonial and 19th Century Bolivia. The exhibit opens May 15, 1984 and closes June 24, 1984. A full-color catalog that discusses the origins of the Aymara textile forms and their development will be sold in the museum Book Shop.

THE ETHNIC ARTS SHOP
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